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The Portable Electric Drill.

ELECTRICITY AS A FACTOR IN CIVILIZATION.—[See page 55.]

# Control and Operation of High Voltage Transmission Systems*

By Charles P. Steinmetz, Chief Consulting Engineer, General Electric Company

In a consideration of the problem of controlling and operating high voltage transmission systems, the first question which arises is, what is high potential? To the bell hanger of the early days, the 110-volt incandescent lamp circuit was high potential, while the modern transmission engineer considers the 11,000-volt generator circuit as low potential. For the present purpose, the dividing line between high potential and low and medium potential is best drawn at that voltage at which the electrostatic capacity of the transformer becomes appreciable, since it is at this point that phenomena appear which do not exist at lower voltages, and which require a material change in the methods of control of the system to insure maximum safety and thus reliability of operation.

Theoretically, every electric circuit has capacity as well as inductance, and every circuit therefore stores energy electrostatically (or dielectrically, as more preferably called) and electromagnetically, through capacity in the dielectric field of the voltage and through inductance in the magnetic field of the current, respectively. At medium voltages, the only circuits in which the electrostatic capacity is sufficiently large to make itself felt are the overhead lines and underground cables; while in generators, transformers, etc., the electrostatic capacity is so small as compared with the inductance that the electrostatic energy is negligible and the circuit acts as one containing inductance, but not capacity.

In such an inductive circuit without capacity, the only change which can occur in the stored energy is an increase or decrease, such as accompanies the inductive discharge which occurs when operating a motor field; oscillations, waves and impulses cannot exist, and when such oscillations or waves approach an inductive circuit (as from a transmission line) they cannot enter it, but are stopped and reflected at its terminals. They then produce high voltage differences at the end turns of the inductive circuit, which may be represented by a transformer. Since in an inductive circuit without capacity the high voltage which may be produced by an electric wave approaching it, as lightning, is limited to the terminals, effective protection can be secured by extremely heavy insulation of the end turns as is customary in transformer construction, or by inserting an inductance—a choke coil—between the transformer or generator and the line. The high voltage then appears between the turns of the inductance, but does not reach the transformer, or reaches it with greatly reduced intensity.

Oscillations, stationary waves, traveling waves and impulses can exist only in circuits containing electrostatic capacity as well as inductance. At medium voltage, the electrostatic capacity of the transformer is negligible, as we have seen; it increases at a very high rate, however, with increasing voltage. The stored magnetic energy of the transformer is given approximately by its reactance voltage (commonly called "impedance voltage") times the current. In modern power transformers, irrespective of the voltage, the reactance is usually chosen between 4 and 6 per cent,[1] and the stored magnetic energy thus equals approximately from 4 to 6 per cent of the transformer rating.

If we assume a transformer rebuilt for $n$ times the voltage, then the length, and with it the capacity of the high potential winding, is approximately $n$ times as great as before, and at $n$ times the voltage thus gives $n^2$ times the capacity current, since the capacity current is proportional to voltage times capacity. At $n$ times the voltage, $n^2$ times the capacity current gives $n^2$ times the capacity volt-amperes, which represent the stored electrostatic energy.

This rapid increase in the capacity energy of the transformer with increasing line voltage means that the voltage at which the capacity effect becomes appreciable is fairly definite—about 60,000 volts. Hence below 60,000 volts the transformer is an inductive apparatus, into which oscillations and waves cannot penetrate; above this voltage, the high potential coil of the transformer is a circuit capable of oscillations and electric waves, into which oscillations and other disturbances from the transmission line can enter, can traverse the transformer winding and form nodes and voltage crests inside the transformer. This accounts for the fact that line disturbances occasionally produce breakdowns far inside of the high potential transformer winding. The choke coil which protects the transformer at lower voltages may then become a source of danger: while it still keeps line disturbances away from the transformer, it at the same time obstructs the exit into the line of oscillations and other disturbances which originate in or at the transformer, and by reflecting them into the transformer increases their voltage and thereby their destructiveness.

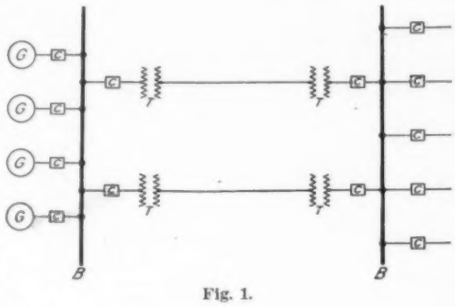

Fig. 1.

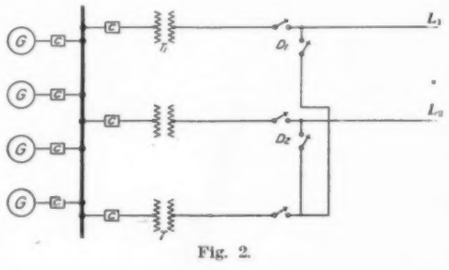

Fig. 2.

The most frequent, and therefore most serious source of high voltage high frequency disturbances is switching; and especially dangerous is switching at the transition point between two oscillating circuits of different character, such as a transmission line and a transformer high potential coil. Thus high potential switching between transformer and transmission line is dangerous, especially to the transformer, and should be avoided as much as possible.

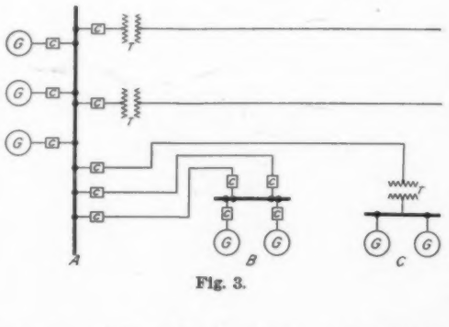

Fig. 3.

As seen, this applies only to those high voltages where the transformer capacity is appreciable and the transformer thus capable of oscillating. At lower voltages, where the transformer is a simple inductive circuit, switching between transformer and line is harmless and is the usual custom, as the impulse wave produced at the switch cannot enter the transformer and is taken care of by the extra insulation of the end turns or by the choke coil. On the other, or line side, the impulse passes into the line and is rapidly dissipated by the line resistance, without giving rise to abnormal dangers. Thus the danger of switching, where such exists, is found not in the line but in the apparatus connected to the line. This is not always realized.

In the control and operation of high voltage transmission systems it is therefore strongly to be urged that all the switching be done on the low tension side of the transformers, where it is practically safe; and preferably to have no circuit breakers between transformer and transmission line, but to connect the transformers permanently to the line and consider them as a part of the line. The safest arrangement would therefore be as indicated in Fig. 1, where $G$ represents the generator, $T$ the step-up and step-down transformers, $B$ the low tension busbars, and $C$ the circuit breakers. Disconnecting switches, that is, switches which can be opened only when there is no voltage on the circuit, would obviously be installed on either side of every transformer and circuit breaker, so as to isolate this apparatus for inspection or repair. As will be seen, in this case the high potential lines are separated and the paralleling done only on the low voltage side of the transformer. This offers the advantage that a ground on one line does not ground the other line also.

A frequent objection to such an arrangement is, that a disabled line also puts its transformers out of service, and arrangements are therefore desired for connecting every transformer or generator to every line. This can be done, but usually leads to such a complication in the switching and controlling arrangement that the gain is not comparable with the increased risk of accident resulting from the greater complexity of the arrangement. In very high voltage circuits especially, the simplest possible arrangement offers such an advantage in reliability that every effort should be made toward it.

In general, a spare transformer unit would probably be provided, so that in case of a breakdown in a transformer unit, its transmission line could be maintained in operation. Without material decrease in simplicity, the arrangement shown in Fig. 2 might then be used, in which $T$ shows the spare transformer unit, which can be connected to either line by the disconnecting switches $D$. If then transformer $T_1$ burns out, its circuit breaker $C_1$ cuts line $L_1$ off the busbars. By means of the disconnecting switches $D_1$, the line $L_1$ is then disconnected from transformer $T_1$ and connected to transformer $T$, and the latter then energized by its circuit breaker $C$.

This operation involves a shut down of line $L_1$; but it is probable that with two lines in a high voltage transmission system, a transformer burn-out in one line would usually shut down this line in any case. The same arrangement can then be used, in case of a breakdown of one line, to connect the spare transformer to the other line and carry double load over it, without a corresponding margin in transformer capacity.

While high potential switching is dangerous and should be avoided between oscillating circuits of different character, such as line and high potential transformer, it is harmless, as we have seen, between line and inductive circuit. It also is harmless between oscillating circuits of the same character, such as sections of the line, and therefore no serious objection exists against high potential switching between branch lines and main lines, or against high potential switching in the main lines at considerable distance from the stations for the purpose of sectionalizing the lines, in order to cut out a disabled section of a line and operate the rest of it in parallel with the second line. However, in case of line switching, any transformer located near the switching point would be endangered, and would thus require special protection.

The case where a simple arrangement of lines and transformers with low tension switches becomes difficult to arrange without material sacrifice in the flexibility of the system, occurs where several stations feed into the same transmission lines. Where the stations are near together, it is often feasible (and then very desirable) to use one station only as transformer station and feed from the other stations at a lower voltage (6,600 or 11,000 volts) into the low tension busbars of the main station, as indicated for station $B$ in Fig. 3. This offers a convenient way of utilizing induction generators in smaller stations and thereby eliminating practically all control from the smaller stations; that is, control them from the main station, as indicated at C in Fig. 3.

Naturally, in the manifold requirements under which transmission systems have to operate, instances will always occur where high tension switching is unavoidable, and thus no rigid rule can be established. Obviously, the larger the number of lines and of transformers which are connected together, the less are the disturbances, and with it the danger resulting from disconnecting one of the lines or transformers.

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[1] In the early days, transformers had impedances of 15 to 20 per cent, and thereby gave poor voltage regulation. To improve the voltage regulation, the designs were changed to those giving lower impedance, so that finally impedances as low as 1 to 2 per cent were produced. Then, however, experience showed that in high power systems such transformers are unsafe, owing to the enormous strains produced on the transformer and the system by the excessive starting currents, and, in case of accidents, by the excessive short circuit currents permitted by such low impedance transformers. This made it necessary to increase the reactance and devise transformer designs of 4 to 8 per cent reactance. In high power central station practice, this danger has been forcibly impressed upon the operators, and usually a sufficiently high reactance is specified for the transformers to give reasonable safety of operation. In transmission practice the recognition of the necessity of a reasonably high transformer reactance, to insure safety of operation, is not yet so universally recognized.

# Elements of Theoretical Aeromechanics*

## Part II Continued—Aerodynamics

By A. F. Zahm, Ph.D.

Continued from SUPPLEMENT, July 20, 1912, Page 38

*Principle of the Conservation of Momentum.*—Thus far we have studied the motion of fluids by aid of the principle of the conservation of energy, and by its means have found the relation between the pressure, velocity, and density at all points of the moving fluid, as expressed in Bernouilli's theorem. In like manner we may obtain many useful results from another fundamental principle of physics, known as the principle of the conservation of momentum.

Broadly stated, this principle asserts that a system of bodies cannot change their aggregate momentum by mutual action. For example, a gun throws a projectile northward, and is itself hurled southward with equal and opposite gain of momentum. The earth draws an apple downward, and is itself drawn upward. The impulse of the one is equal and opposite to the impulse of the other, being measured by the product of the mass into its gain of velocity. In other words, the velocities gained by propellant and propelled are inversely as their masses. Furthermore, since the gain of momentum per second is a measure of the force causing it, propellant and propelled are urged apart with equal and opposite forces. This much for linear motion; for angular motion a like relation obtains. The angular momentum per second communicated is equal and opposite to that received, and is a measure of the angular force, or torque, causing the angular velocity. What has been said of the generation of linear and angular momenta applies also to their destruction. It takes a given force as long to stop a certain free motion as to start it.

Many practical problems in fluid dynamics may be solved directly by use of the foregoing principle. If, for example, a jet of air or water issues from a tank, its reaction, or back pressure, on the tank equals the momentum per second communicated by the tank to the jet, or the mass per second times the velocity. Likewise, when the jet strikes squarely on a plane surface and flattens out, losing its forward velocity, it exerts a pressure equal to the mass per second of the impinging fluid multiplied by its speed. Thus, if $\rho$, $a$, $v$, be the density, sectional area, and velocity of a jet, its reaction against the tank ejecting it, and the pressure against a normal plane stopping it, each equals in numerical magnitude $\rho\ a\ v^2$, this being the product of the velocity of the impinging jet multiplied by the mass per second, $\rho\ a\ v$, of fluid delivered by it.

In particular, if the jet has a cross-sectional area of one square unit, its whole impactual pressure against the plate will be $\rho\ v^2$, providing the plate be broad enough to stop the forward velocity. This total pressure of the flattening jet is just twice the unit pressure at the center of impact as previously calculated. Hence, if the plate be pressed against a unit orifice in a tank, it will support a fluid column of twice the "height due to the velocity," or twice the height of the source. Putting it numerically, if a one-inch stream of water, from a tank of ten feet head, strikes squarely against a flat plate stopping a one-inch hole in a second water tank, it will sustain in the second one a head of nearly twenty feet. This phenomenon may be verified experimentally, and is sometimes called the "hydraulic paradox;" because, while the back pressure, or reaction, of the stream against the first tank equals the impact pressure against the second, the water level is twice as high in the second as in the first. The puzzle is resolved by noting that the impact on the plate is sustained by just one square inch of static fluid surface in the second tank, while in the first tank, or source, the issuing one-inch jet exerts its back pressure against a static fluid surface of more than one square inch, as may be seen by tracing the jet back into its source to where it comes practically to rest. The phenomena may be varied by curving the periphery of the plate so as to make the stream rebound, thus still further increasing the impactual pressure, and heightening the fluid in the second tank. Obviously, the fluid in the second tank may be sustained at any height whatever, by force of the given jet, if the given plate be made to close an aperture sufficiently small. But in all cases it must be noted that, as formerly calculated, the unit pressure at the center of impact equals the pressure of the source, so that if a pin-hole be made there in the plate, the level in the second tank cannot exceed the level of the source.

What has been said of a steady horizontal jet issuing from a reservoir may be affirmed also of a stream hurled from a propeller. Its reaction on the propeller equals the impulse of the stream against a broad normal plane which just stops its forward velocity; while both reaction and impulse severally equal, in numerical value, the change of momentum per second required to maintain or stop the propeller stream. This statement, of course, is true of all propellers. But in applying the principle to a practical case there is need of precaution. For if a closed circulation occur, so that the fluid issuing from the rear of the propeller gradually returns to its front and passes through without being started from rest, or practically so, the formula derived for the jet is not precisely applicable, but gives an excessive thrust. In a small, clear room the circulation may be so free as to make the thrust less than half that it would be in the open.

When the momentum principle is employed, the propeller thrust may be written, $R=m\ v$, in which $m$ is the mass of fluid per second set in motion, and $v$ is the velocity imparted. This shows that the propeller thrust increases directly as the velocity imparted per second to a given mass of fluid. Accordingly, aeronauts sometimes think it advisable to hurl the air with immense speed. They might not be so far wrong if they had unlimited engine power free of cost. But the formula also shows that a large thrust may be had by hurling a large stream at slow velocity.

The principle of the conservation of momentum applies in like manner when a stream, instead of being started or stopped, is merely diverted. If a jet of velocity $v$, striking an oblique object, like the curved blade of a turbine or water-wheel, suffers a loss of forward velocity represented by $v_1$, and acquires a lateral component of velocity $v_2$, it exerts on the object a forward impulsive pressure $s\ a\ v.v_1$, and a lateral pressure $s\ a\ v.v_2$, $a$ being the cross-sectional area of the jet; while the entire impactual force against the diverting surface is the resultant of these two rectangular components. Obviously, if $\alpha$ is the angular deviation of the jet, at unabated speed, its lateral gain of velocity is $v_2 = v\ sin\ \alpha$, and its loss of forward velocity is $v_1 = v\ (1—cos\ \alpha)$, this latter being the difference between the velocity before impact and the forward component of velocity after impact; and these values of $v_1$, $v_2$, substituted in the foregoing equations, give the rectangular components of the whole impulsive pressure of the jet.

As a practical application of these formulæ, if the stream from a propeller encounters a large aeroplane surface, or sail arched downward, it will exert a lift on the sail whose magnitude equals the down-increment of momentum per second, and this is evidently equal to the whole momentum per second of the propeller stream multiplied by the sine of the angle of deviation. The maximum lift so obtainable is therefore not greater than the propeller thrust, and this occurs when the stream is turned straight downward with unabated velocity. At the same time the drift, or rearward pressure on the aeroplane surface, approximately equals the propeller thrust multiplied by one minus the cosine of the angle of deviation of the stream, as above explained. These relations should have due consideration by those inventors who propose to lift an aeroplane vertically in space by directing the propeller stream against its wings. Doubtless the feat is physically possible, but it requires far more power than to support the same weight in the customary way, unless the wings be so shaped and so near the earth as practically to imprison the air beneath them. In this latter case a small motor could lift an indefinitely heavy aeroplane.

If the jet impinge on a flat plane of inclination $\alpha$ and be diverted by this amount, the change of velocity normal to the plane is obviously $v\ sin\ \alpha$ and the consequent impactual unit pressure for a jet of unit cross-section is $\rho\ v^2\ sin\ \alpha$. The rectangular components of this force, forward and lateral, are found by multiplying it respectively by the sine and cosine of the angle of impact. Thus, the forward force exerted by the unit jet is $\rho\ v^2\ sin\ \alpha$.

So much for the theory of jets, or narrow fluid streams. One naturally inquires what is the whole impactual pressure on a body immersed in a very large stream like the wind. It must be said that no satisfactory general analysis of the resistance of surfaces submerged in natural fluids, under ordinary conditions, has yet been worked out, so that the only reliable resistance values are those obtained by cautious and skilful experimentation. For a fluid, however, composed of small discrete particles widely separated, whose impact occurs without mutual influence, the pressure can be computed by the simple method employed for the narrow jet striking a broad plate. Such a fluid was hypothecated by Sir Isaac Newton, and yielded formulæ which may be fairly true for very rarefied gases, but which in general are far from true for fluids under ordinary pressures.

In the Newtonian analysis each filament of the fluid stream is assumed to encounter the submerged obstacle uninfluenced by any other filament. If the impact is perfectly inelastic, the particles lodge or flatten out on the submerged obstacle; if it is perfectly elastic they rebound with unabated speed, but with altered direction. In either case the whole pressure of impact, and the exact stream paths, can be readily calculated for any given form of geometrical surface by treating each filament separately and summing the effects of all.

Consider a submerged plane surface. If a plane is set normally in such a current it sustains, on each square unit of its surface, a pressure equal to $\rho\ v_2$, since each unit of surface is bombarded by an independent jet, delivering $\rho\ v$ units of fluid mass per second against the plane, and each unit mass suffers a change of velocity $v$, assuming perfect inelasticity. The whole resistance of the plane is, therefore, $\rho\ a\ v^2$, $a$ being the area of the plane, which expression has the same form as that for a single fluid jet. If the plane is more and more inclined, fewer filaments strike, and each with an impact softened by the obliquity; but the impactual pressure is easily computed by taking account of the angular deviation, as explained for a single jet. For perfectly elastic impact the resistance is, of course, twice that for inelastic impact, since the change of velocity component normal to the plane is twice as great for elastic as for inelastic impact, the component velocity parallel to the plane having evidently no influence on the impactual pressure, since it remains unaltered and occasions no change of momentum in the impinging stream. Thus, for a plane of area $a$ and inclination $\alpha$ the sectional area of the intercepted stream is $asin\alpha$, the unit-jet pressure for inelastic impact is $\rho v^2 sin\alpha$, and the whole pressure is $\rho a v^2 sin^2 \alpha$.

The forward and lateral components of this force are found, as before, by multiplying by the sine and cosine of $\alpha$. Thus the forward component is $\rho a v^2 sin^3 \alpha$.

In a similar way the flow and resistance may be found for spheres, cones, ellipsoids, and other geometrical forms. In all these it will be observed that the particles strike only the front surface, where they lodge or else rebound, then speed away without touching the rear or exerting pressure upon it. Such effect may occur in the highly-rarefied atmospheres of planets when struck by meteorites, and less fully in the motions of very high-speed projectiles, which are immediately followed by a rarefied and feeble wake. In general, if the rear pressure can be neglected, the resistance of a given object can be said to vary directly as the square of the velocity; for it is measured by the mass per second of fluid disturbed times the velocity of disturbance, thus involving the velocity to the second power, as in the case of the normal plane above considered.

A numerical value of the atmospheric resistance to a normal plane may be derived from the foregoing formula $\rho\ a\ v^2$, and is of some historical interest. Writing the density $\rho$, of the air equal to one-thirteenth of a pound per cubic foot, and $a$ equal to one square foot, the pressure per square foot becomes $v^2/13$ poundals, in which $v$ is the velocity in feet per second. Expressed in pounds force and miles per hour, the resistance per square foot is easily found to be $v^2/200$. This value is sometimes given in text-books, and is said to have been found experimentally by certain early investigators, but is now known, from more accurate measurements, to be some fifty per cent greater than the true value.

An analytical discussion, compared with experiment, giving the resistance of bodies in fluids when the impactual pressures on front and rear are taken into account, will be found in Col. Duchemin's work on the laws of resistance of fluids. His general equation for the resultant impactual pressure on any blunt body, or any plane surface moving normally through the air, is for ordinary speeds of transportation, $k\ s\ a\ v^2$, in which $k$ is a numerical constant for the given surface. For higher speeds he obtains a formula involving both the square and cube of the speed.

* Abstract from the author's treatise on aeromechanics, reproduced from the *Journal of the Franklin Institute.*

# The Royal Society

## Celebration of the 250th Anniversary of the Foundation

On July 15th, 1912, the Royal Society of London celebrated an anniversary which is significant of the rise, growth and continuity of a great institution, now rooted deeply in British national life. On that day the society became 250 years of age, and this fifth jubilee of its birth was marked by ceremonies and festivities of a special character. Certainly it was not expected that such an epoch would be met with chill indifference in this the age of scientific progress and discovery, and hence the decision to invite its recognition was universally welcomed as most proper and fitting, more especially since on no previous occasion in the society's history has any landmark of time been singled out for observance. Delegates representing the chief scientific societies, universities and learned bodies of the civilized world participated in the commemoration. Sir Archibald Geikie, K.C.B., the president, received from them at Burlington House congratulatory addresses on the auspicious occasion.

### "DIVERS WORTHY PERSONS."

The Royal Society took shape and being from the meetings of a small group of men who were severally interested in that new or experimental philosophy which was the dream and intellectual exercise of Francis Bacon, and promulgated in his "Novum Organum" and "New Atlantis." "About the year 1645," writes Dr. John Wallis, the mathematician and scholar, "at a time when, by our civil wars, academical studies were much interrupted in both our universities, I had the opportunity of being acquainted with divers worthy persons, inquisitive into natural philosophy, and other parts of human learning. We did, by agreement, meet weekly in London, on a certain day. Our business was to discourse and consider of philosophical enquiries—physick, anatomy, geometry, astronomy, navigation, staticks, magneticks, chymicks, mechanicks and natural experiments; with the state of these studies as then cultivated at home and abroad."

These men, among whom were John Wilkins, D.D., Dr. Francis Glisson, Dr. Goddard, and Theodore Haak, met in the lodgings of one or other of their number; at the Bull-head tavern, Cheapside, or at Gresham College, Bishopsgate Street, or in the Middle Temple. The removal of some who were in this circle to Oxford (1648-9) did not, however, lessen the efforts of the remainder, where "inclinations lay the same way." Meetings took place at Oxford, and the new studies were brought into fashion there. Dr. Seth Ward (afterward Bishop of Salisbury), John Wilkins (Warden of Wadham College), the Hon. Robert Boyle and Dr. (afterwards Sir William) Petty, were active promotors. The outcome of these gatherings was the foundation, in 1651, of the Philosophical Society of Oxford. The meetings of the London philosophers were continued at intervals until about the year 1658, usually at Gresham College, the company now including Viscount Brouncker, Christopher Wren, John Evelyn, Sir Paul Neile, Dr. Croone, Dr. Timothy Clarke, and Sir Robert Moray, together with those sympathizers who were now and again able to attend from Oxford. Soon the political upheaval and the events which the capital witnessed made further meetings at Gresham College impossible. The place was turned into a barrack for soldiers, and the assembly dissolved of necessity. After the restoration Gresham College once more held its own. On November 28th, 1660, a step in advance was made. After hearing a discourse in the college by Wren (he held the chair of astronomy under Sir Thomas Gresham's foundation), the company did, "according to the usual manner, withdrawe for mutuall converse" into Mr. Rooke's chamber. Among other matters that were discoursed of, "something was offered about a designe of founding a colledge for the promoting of Physico-Mathematicall Experimentall Learning."

The idea of a society or fellowship which would have definite aims concerning the promotion of experimental learning was, we see, beginning to shape. Before they separated the company drew up, and thereupon recorded a list of persons judged likely to be in sympathy with the project; fixed upon a subscription (one shilling a week), and appointed a chairman, treasurer, and "register." Meeting on December 5th, 1660, the assembly, now largely reinforced, signed an obligation of voluntary association for the purposes in view. This historical document, a fragment of English history, includes the signatures of such notable men as Robert Boyle, Christopher Wren, Elias Ashmole, John Evelyn, John Wallis, Seth Ward, Cowley (the poet), John Dryden (the poet), and Henry Oldenburg. A staunch friend was early found in the courtier Sir Robert Moray, who, as recorded in the first journal book, brought word that the king had been acquainted with the "designe," did well approve of it, and would be ready to give encouragement. Next provisional rules of constitution were drawn up. The mode of electing members was decided on; the number of standing officers, and the servants of the society. Of the latter there were to be two, an amanuensis and an operator, the salary of the operator to be "foure pounds by the yeare." On March 6th, 1660-1, Sir Robert Moray was chosen to preside over the gatherings, sharing the duty

Mace of the Royal Society, Presented by King Charles II. in 1663.

as time served, with Dr. Wilkins and the Hon. Robert Boyle. Gresham College was adopted as the place of venue for the members.

### PATRONAGE OF KING CHARLES II.

As was but natural, the leaders of the organization were now anxious, after Moray's intimation, to draw closer the ties of encouragement extended by Charles II and secure incorporation by charter. Already his Majesty had discussed various matters with the philosophers. Evelyn, the diarist, records, May 3rd, 1661, that, together with Lord Brouncker, Moray, Neile, and one or two others, they had shown Saturn's rings and Jupiter's satellites to the King, "thro' his Majesty's great telescope, drawing 35 foote." The Society's own records indicate also the royal interest. An entry of September 4th, 1661, reads: "Some papers were delivered in to the society by Sir Paul Neile from the King, and endorsed with his Majesty's own hand, and ordered that they be registered; they were about Mr. Hobbes mean proportionalls." On September 18th following, Sir Robert Moray read a petition "to the company," and it was directed to be delivered to the king in the society's name. The result of this activity is made clear by a journal book record of October 16th, 1661, when "Sir Robert Moray acquainted the Society that hee and Sr. Paul Neile kiss'd the King's hands in the Company's Name, and is intreated by them to return most humble thancks to His Majesty for the Reference he was pleased to graunt of their Petition: and to this favour and honour hee was pleased to offer of him selfe to bee enter'd one of the Society."

If not the actual originator of the designation "Royal Society," John Evelyn was the first, at any rate, to use this term publicly in direct reference to the philosophic assembly of which he was a member. His translation of a work by Gabriel Naude, which appeared in 1661 under the title "Instructions concerning erecting of a Library," contained a dedication to the Earl of Clarendon, and herein he writes of the "promoting and encouraging of the *Royal Society*." His colleagues amphasized their satisfaction by the following resolution: "Upon a Report made to this Honourable Company that Mr. Evelyn, one of their Members, had done honour to this Company before, in an excellent Panegyrick, i. e., a poem on his Majesty's coronation to the King's Majesty, and since, in an Epistle Dedicatory, addressed to the Lord Chancellor, in which with much eloquence and high expressions of honour he mentions this Company, and its designe, and most affectionately recommends it to the King's Majesty, the Company were soe sensible of the great favour done them by this worthy Person that at their last meeting they ordered their thanks to be given him."

### ROYAL CHARTER.

On July 15th, 1662, the Great Seal of the Kingdom was affixed to a charter of incorporation, and the Royal Society entered into being and became a national body. Inferentially, it was charged to encourage philosophical studies, especially those which by actual experiments might attempt either to shape out a new philosophy or to perfect the old. The King became founder, patron, and companion. William, Viscount Brouncker, was nominated the first president, and John Wilkins and Henry Oldenburg, secretaries. It was the particular pride of Evelyn that, by this charter, he was nominated a member of the first council. Profoundly grateful for favor received, upon the reading of the letters patent it was voted that the president, attended by the council and as many of the society as could be obtained, should wait upon his Majesty after his coming from Hampton Court to London, to give him humble thanks for his grace and favor. The president was empowered to acquaint the king with the society's wishes; afterward the Lord Chancellor was to be thanked, and Sir Robert Moray also for his concern and care in promoting the constitution of the society into a corporation. Subsequently Lord Brouncker gave an account to the society of his and the council's address, and how that the president and Fellows kissed the king's hand. On April 22d, 1663, upon intercession, a second royal charter was issued, which secured further privileges, and granted a coat of arms. By both charters the right was given, under warrant, to demand and receive the bodies of malefactors and to anatomize them. This permit, however, early fell into abeyance.

It was long hoped and expected that King Charles would attend one of the meetings. A committee was, in fact, appointed to consider the manner of his reception, and the preparation of suitable experiments, one of these being the contriving of optical pictures. But, however good his Majesty's intentions, he never came.

### A MACE AND SEAL.

The gift of a mace was a further mark of royal recognition. This symbol, which bears the royal arms (the arms of the society were added later), is of silver, richly gilt; on the head are embossed figures of a rose, harp, thistle and fleur-de-lys, on each side of which are the letter "C. R." At one time the belief was current that this mace was the "bauble" which Cromwell disowned in the House of Commons; in effect, that Charles II. passed it on, in convenient season, to the newly founded Royal Society. The discovery, in 1846, of the original warrant issued in 1663, authorizing the delivery to Lord Brouncker of "one guilt mace," being a guift from His Majestie," happily ended all doubt on the subject.

The making of a common seal was intrusted, in 1666, to Thomas Simon, formerly medallist and seal and coin engraver to Cromwell. A noteworthy instance of its use early in the following year is afforded by the resolution that "the Amanuensis do handsomely write the Diploma for Mr. Hevelius (the famous Dantzig astronomer who charted the lunar surface) upon parchment, and that Mr. Simon be desired to attend for taking off the Seal and to have a silver box to put the Seal in." The procedure was, however, changed, for it was ordered that "the President take home with him the seal to have it handsomely taken off by Mr. Simon for Monsr Hevelius his Diploma; and that the Amanuensis get the ornaments of the said Diploma ready against Satturday morning and carry it to the President; and that thereupon the Secretary dispatch it away."

ARUNDEL HOUSE IN THE STRAND.

We have seen that both before and after the restoration the society's home was at Gresham College. The outbreak of the plague in 1665 dispersed the company. Met together again, the disaster of the great fire of London in the following year necessitated removal from the college in order to give room to the magnates of the city. The philosophers were homeless, and indeed, much perturbed as to where they should go. However, Mr. Henry Howard (afterwards sixth Duke of Norfolk) opportunely came to the rescue, by offering accommodation at Arundel House, in the Strand, apparently through the intervention of Evelyn. Howard was not at the time a fellow of the society. The first meeting was held there on January 9th, 1666-7. Pepys tells us that Mr. Howard was present, and my Lord Brouncker made a congratulatory speech, but "did do it in the worst manner in the world." In May of this year a fair visitor of quality and fashion—the Duchess of Newcastle—came to Arundel House in great pomp to witness experiments. Her Grace had desired to be formally invited, and the wish was gratified, though it occasioned a vote of members of council, since some appeared to fear the chaffing arts of the ballad-mongers of the day. The experiments shown comprised the weighing of air, action of magnets, and mixing of colors.

For upward of seven years the society foregathered in the Strand, returning thence to its former quarters. Evelyn (December 1st, 1673) makes comment: "To Gresham College whither the city had invited the Royal Society by many of their chief aldermen and magistrates, who gave us a collation, to welcome us to our first place of assembly, from whence we had been driven to give place to the City on their making it their Exchange, on the dreadful conflagration, till their new Exchange was finished, which it now was."

Lord Brouncker presided at the Gresham College meetings as heretofore, retiring in 1677 after fourteen years' faithful service. He was succeeded by Sir Joseph Williamson, and next, in order of election, by Sir Christopher Wren, Sir John Hoskins, Bart., Sir Cyril Wyche, Samuel Pepys, the Earl of Carbery, the Earl of Pembroke, Sir Robert Southwell, Charles Montagu (afterward Earl of Halifax), Lord Chancellor Somers, and (1703) Isaac Newton, who was the last of the Gresham College presidents. Newton was knighted by Queen Anne in 1705. Singularly enough, Charles Montagu and Lord Somers were each made president on the very day on which they were respectively elected into the society, from which it would appear that, by common consent, they were brought in with a view to office. The latter did not attend the meetings for some time, and when he did it was recorded that "My Lord Chancellor did ye Society ye honour to preside, after having viewed ye Library and Repository and seen some Experiments in ye Pneumatick Engine" (i. e., Boyle's air-pump). Newton also showed some experiments on this occasion.

Already the society had begun to form a gallery of portraits, the nucleus of its present fine series. We read in "A New View of London" (1708) that in the meeting room at Gresham College hung portraits of Robert Boyle, Southwell, Halley, Spelman, Wilkins, Lord Brouncker, Wallis Hobbes of Malmesbury, Harvey, and Pepys. A repository or museum of "natural rarieties" was, too, an early object of solicitude, a large number of specimens being received and arranged. The contents, or such as were in a fit state, were handed over to the British Museum in 1779.

A GREAT SECRETARY.

No account of the Royal Society in its early times would be complete without mention of Henry Oldenburg, who was nominated by the first charter joint secretary with Dr. Wilkins. A native of Bremen, he settled in England, and was for a time officially engaged under Cromwell. He was a correspondent of Milton, Leibnitz, and Spinoza. Taking up residence at Oxford in 1656, he came into the circle of those who were interested in the new philosophical learning. To this intercourse and personal enthusiasm is due his selection in 1663 as one of the two secretaries of the incorporated society. For fourteen years, till his death, Oldenburg labored indefatigably and exclusively in its interests. He maintained a voluminous correspondence with philosophers abroad, and reported the results. Had he been less active in this respect he would not have been incarcerated in the Tower in 1667, charged, strange as it may seem, with "dangerous plans and practices." Writing in that year to Governor Winthrop, of Connecticut, Oldenburg says: "Sir, you will please to remember that we have taken to taske the whole Universe, and that we were obliged to doe so by the nature of our Dessein. It will therefore be requisite that we purchase and entertain commerce in all parts of the world with its most philosophicall and curious persons." He was kept in the Tower for two months before his real dealings pierced the thick veil of suspicion.

THE "PHILISOPHICAL TRANSACTIONS."

During Oldenburg's secretaryship, the publication of the world-renowned "Philosophical Transactions" was begun, a work still regularly issued by the society. The first number appeared March 6, 1664-5. Among the contents were "An Accompt of the Improvement of Optick Glasses," and a review of a work by Robert Boyle Number 24, April, 1661, contained "Directions for Observations and Experiments to be made by Masters of Ships, Pilots, and other fit Persons in their Sea Voyages," from suggestions by Sir. R. Moray and Robert Hooke. Of this paper one hundred extraordinary copies were ordered to be printed off for Trinity House, as being of interest to seamen. Though there was much in the early "Transactions" that was of solid value, many papers and reports of a trivial and credulous character were, nevertheless, intermixed. To wit: "Sir Richard Bukeley produced a letter from Mr. William Molyneux, somewhat calling in question an account which he had before sent out of Ireland concerning a girl, who discharged grains of wheat, barley, etc., out of the corners of here eyes; for that a person there, upon trial, found, that without pain or trouble, he could easily hide several grains under his eyelid, which of themselves will start out, unless kept back with the finger." The times were not ripe for the true understanding of facts.

SIR ISAAC NEWTON.

Newton, the great legislator of science, whose discoveries changed the current of the world's thought, received the laurel of the presidency in 1703, and held office for twenty-four years. It was in the plague year of 1666 that he began to investigate the question of gravitation. In a foreword, on April 21st, 1686, Edmund Halley stated that his worthy countryman Mr. Newton "has made out all the phenomena of the celestial motions so easily and naturally that its truth is past dispute." At a meeting of the Royal Society seven days later Dr. Vincent presented the manuscript of the immortal "Principia," when it was ordered that Halley should make a report thereon. The latter printed it at his own cost, the book appearing in 1687. As a matter of fact, the society, having just been at the expense of printing Willughby's "History of Fishes," were without funds. They could go no further, and but for Halley's timely intervention the issue of the "Principia" might have been indefinitely delayed. Most surely Halley's name is recalled with gratitude on the occasion of this anniversary.

The controversies which centered round Newton's discoveries need no recapitulation here. "Philosophy," said he, "is such an impertinently litigious lady that a man had as good be engaged in lawsuits as have to do with her." During his presidency the society widened its conceptions, emerging from the chrysalis stage, as it were, by casting the shell of loose speculation.

Henceforth the investigation of natural laws and phenomena were of different moment.

Newton received burial in Westminster Abbey, where also, a century and a half later another great president, Lord Kelvin, was laid to rest. There, too, lie the remains of Herschel, Lyell and Darwin. The commemorative service which it had been arranged should take place in the Abbey as part of the proceedings of the anniversary, bears consequently a significance which will not be lost on those privileged to participate.

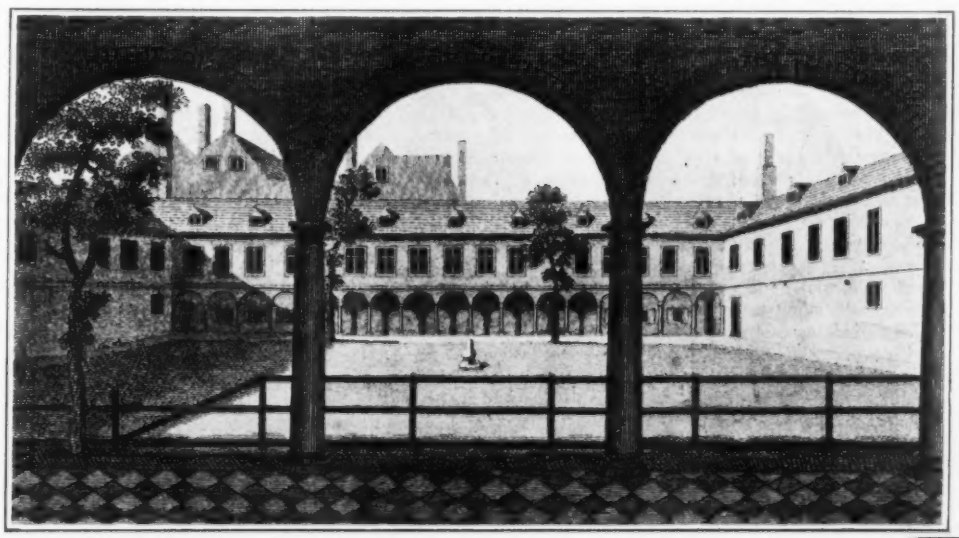
CRANE COURT.

In 1710 the Society moved westward from Gresham College to Crane Court, Fleet Street, having bought the house and garden of Dr. Barbone on the recommendation of Newton that the place was "in the middle of the town and out of noise." There, on the vacant land, they built a hall known as Newton Hall. In 1877 Barbone's old domicile was burnt down, but the detached hall escaped destruction. In 1780 rooms for the Society were granted in Somerset House, where they remained until 1857, removing them to Piccadilly.

LECTURESHIPS AND MEDALS.

Two old-established lectures, the Croonian and the Bakerian, are delivered annually. The former derives its name from Dr. Croone, one of the original fellows, who had much to do with framing the Society's early procedure. The subject relates to the nature or laws of muscular motion. Croone it was who, in 1664, offered an experiment of choking a chicken and reviving it by blowing into the lungs with a quill. Accordingly, it was ordered that the "operator" provide a chicken for the purpose. At the appointed meeting, having choked the chicken with his finger in such manner that there appeared no signs of life, Croone put a slender glass pipe into the bird's throat, and blew air into it, whereupon, says the record, within a little time the chicken came to itself and lived again. But the learned ones present were not wholly satisfied, so ordered what modern science terms a control experiment. At a subsequent meeting two chickens were to be choked, one to be blown into, the other not. The Bakerian Lecture was the foundation, in 1775, of Henry Baker, F.R.S., a son-in-law of Daniel Defoe. The subject deals with natural history or experimental philosophy. To Baker England owes the introduction of the Alpine strawberry, and the rhubarb plant.

Medals have long been regarded as a convenient mode of honorary reward, and of these the Society allots nine. Allusion may here be made to the Copley, Royal, Rumford, Davy, and Hughes gifts. The Copley originated in a legacy from Sir Godfrey Copley, Bart., F.R.S., received in 1709. Its distribution is carefully restricted, only the most signal services to science qualifying for award. Hence this medal is highly prized both at home and abroad. Two Royal gold medals are annually given by King George V., in continuation of a grant by King George IV., the proposal for their foundation having been communicated to Davy, the chemist, by Sir Robert Peel. The Rumford, established by Count Rumford, F.R.S., in 1796, is awarded for researches on heat or on light. The Count wished, in particular, to encourage such practical improvements in the management of heat and light as tended directly to increase the enjoyments and comforts of life, especially in the lower and more



Gresham College, Where the First Meetings of the Royal Society Were Held.

numerous classes of society. The Sir Humphry Davy medal is given for the most important discovery in chemistry. A service of plate presented to Davy by the coal owners of the Tyne and Wear, to mark the invention of his safety lamp, was bequeathed to the Society to be melted down and sold for the purposes of a fund. The Hughes medal arises from the bequest by Prof. D. E. Hughes, F.R.S., and is to be given for the reward of original discovery in the physical sciences, particularly electricity and magnetism. There has been one lady recipient, viz., Mrs. Hertha Ayrton.

THE LIBRARY.

The Royal Society, as is well known, owns a splendid library of scientific books, while technical periodicals from all parts of the world, suited to its present day needs, are either bought or mutually exchanged with other institutions. It is also the possessor of a choice collection of early printed works, which, though not of a philosophical character, are of special historic interest as being connected with the early history of the Society. They were at once the nucleus of a fine library and an incentive to other gifts. The works alluded to were presented in 1667 by Mr. Henry Howard, of Arundel House (the same who gave lodgment to the Society, as already mentioned), and Evelyn states that it was through his persuasion that Howard parted with them. The choicest works were originally in the library of Matthias Corvinus, King of Hungary, passing afterward to the celebrated Bilibald Pirckheimer of Nuremberg, a friend of Albert Durer. Ultimately they were purchased by Thomas, Earl of Arundel (Howard's grandfather) and brought over to England along with other bibliographical acquisitions. They comprised some 2,500 printed books and 570 manuscripts. Evelyn was concerned as to the quality of Howard's stewardship, holding that he was negligent of them, "suffering the priests and everybody to carry away and dispose of what they pleas'd, so that abundance of rare things are irrecoverably gone." Perhaps the charge was too severe. A portion only of the original collection now remains with the Society. The fine series of manuscripts is in the British Museum. There is one book in the Royal Society's library (how come by is not known) which American bibliophiles would doubtless give much to own. It is a translation into the Massachusetts Indian language of Richard Baxter's "A Call to the Unconverted," made by John Eliot, an English minister, who from 1646 to 1690 was engaged in missionary labors among the Massachusetts Indians. Printed at Cambridge, Mass., in 1664, of a thousand copies known to have been issued in the New World, no example other than that owned by the Royal Society is known to exist. The disappearance of copies is considered as due to their distribution among Eliot's Indian disciples and pupils.

# Etruscan—A Magyar Idiom

## The Disputed Origin of Italy's Pre-Roman Population

By Prof. Alfred Emerson, Art Institute, Chicago

MODERN scholarship has never forgotten the unsolved mystery of the Etruscan race and language. In one of his versified conversations with his patron Maecenas, the Augustan financier, who was himself an Etruscan, Horace accepts the opinion of Herodotus. According to the father of history, Etruria's pilgrim fathers came to central Italy by sea, from Asia Minor. Herodotus relates that a certain king of Lydia had his famine-stricken subjects eat on alternate days, to save their rations. When this arrangement provoked criticism, he told off one half of the population to leave the country in ships. The language of the Etruscan inscriptions, however, reveals no kinship with Lydian, or with any other tongue that was ever spoken in Asia Minor, to our present knowledge. Linguistic scholars have attempted to correlate it with Basque, with primeval Latin, and with the speech of the North African Touaregs. But all in vain. Etruscan epitaphs and dedications are common enough, and are recorded in characters nearly allied to the Greek alphabet. They are not hard to decipher. The meaning of many words can be guessed with a fair chance of hitting the target. Etruscan epigraphists have learned, in the course of these learned exercises at Viterbo and Chiusi and Corneto Tarquinia and Volterra, that the Etruscans followed the odd custom of recording their descent in the female line. The native names that accompany Greek mythologies on engraved bronze mirrors found in Etruria, or on the fresco paintings of underground tombs, acquaint us with the Etruscan Pantheon. Jove was TINIA, Juno THALNA, Venus TURAN, Bacchus FUFLUNS. Achilles is AXLE, and so on. But how shall the erudite specialist interpret a prose selection like the following, which Mommsen has reprinted in his History of Rome to edify and instruct his readers?

Eulat tanna larezul amevachr lautn velthinase stlaafunas sleithcaru.

No wonder, then, if classical scholars have left the Etruscan puzzle to qualified investigators like Corssen, Pauli and Deecke, and to the sparse contributors of *Etruskische Forschungen*. The late W. J. Stillman's proposal that America endow a chair of Etruscan studies at Florence fell on deaf ears. Wilhelm Deecke's adventure with the lost language is still remembered with a smile. After combating Corssen's position that Etruscan is a sort of eocene Latin, for eleven years or so, in his magazine, this able Etruscologist became his dead antagonist's belated convert. His associate Pauli, on the other hand, delivered a dissenting opinion, and seceding from an editorship capable of such abominations, founded a new journal of Etruscan researches to combat Deecke.

The eighteenth century made the language and the history of Etruria a field of willful hoaxes. In the little museum of Viterbo you can still study a lettered marble slab whose prose text, unfortunately a wretched forgery, was once paraded as an authentic contemporary document of an Etruscan prince's prowess in war and peace. I once perused many pages of an old Latin folio "On Royal Etruria," in my student years abroad, before realizing its equally mendacious character. Even honest Dennis propounds some delicious rubbish about the mystic meanings of Etruscan vase forms, in his "Cities and Cemeteries of Etruria." As a matter of fact, their fabric, decoration and inscriptions show nearly all the painted vases found in Etruria to be of Greek manufacture, the product of Corinthian and Athenian potteries. This tallies very well with Pliny's statement that "the brave house of Tarquin," of Tarquinii and Rome, traced its ancestry to a Corinthian exile. Pliny says that this soldier of fortune brought master potters and earthenware decorators to Italy with him, and names these Greek artisans. It is true that their very names betray the share of invention in this learned legend.

The occurrence of Etruscan constructions, tombstones, and bronze utensils, and of earthenwares from the scattered cemeteries of Etruria, which preserve types of composition and ornament unaffected by Greek models, proves the prolonged survival of an artistic tradition in Italy. Upon these native manufactures the Greek importations and colonial factories in that country had little effect. The domestic architecture and stone carving of Etruria was largely Cyclopean and barbarous. It vaguely recalls the rude monuments and carvings of the Celts and Scandinavians, although these had their origin a good thousand years after the downfall of the Etruscan power in Italy. This is not to class the Etruscan antiquities as unworthy of examination. On the contrary, one discovers a fine sense for the opportunities and limitations of their material in the designs of the Etruscan earthenware makers. The antiquarian presently recognizes many historic ties that existed between the early industrial centers, in Italy and out of it. Moreover, adepts in Chinese and Japanese art have noticed a fabulous similarity of certain open-work terra-cotta tabourets from Etruria, upon which the gentlemen of that country deposited their great wassail bowls, with utensils of like purpose and forms that are found in the prehistoric barrows of Japan. That intercourse existed between the Mediterranean and the far East, toward 1000 B. C., is now undisputed, although opinions differ as to whether it moved on land routes or water.

The patriotism of the Roman annalists cannot disguise the fact of Rome's own surrender to the warlike power of its neighbors across the Tiber. Tarquinius Priscus and Tarquinius Superbus were Etruscan princes ruling Rome by right of conquest. Tarracina, well to the south, and Taragona, Spain, confirm the belief that the empire of the Tarquins extended its annexations far beyond the seven hills. It was only when Rome broke with the regal power altogether, toward 500 B. C., that the Latins threw off the detested alien rule. Even so, the Romans retained many features of costume, sacred architecture and ritual which they had learnt from their more advanced neighbors and overlords. The purple toga of the king, the laticlaves of the Roman magistrates, the embroidered toga of the triumphator, the Roman modes of soothsaying by the flight of birds and the entrails of victims, the triple temple of the Capitoline deities, and the clay statue of Jupiter in that sanctuary were derived from Etruria. From 1000 to 500 B. C., the Italian Sea was in fact a Etruscan lake; for the Etruscan confederacy was at that period the first power on the Italian peninsula. Yet Etruria was no true empire, at any time. It constituted a loose confederation, embracing from twelve to twenty kingdoms, duchies and republics, between Pisa at the mouth of the Arno and the mouth of the Tiber. Another older Etruscan confederacy subsisted in the valley of the Po. The Gauls who sacked Rome in 390 B. C. established Celtic colonies upon the wreckage of that northern Etruria, and left the southern a prey to the warlike Latins. In a batch of Graeco-Etruscan terra-cottas I once acquired at Cerveteri there were two figurines of the Gallic warriors whom Brennus led to the very foot of the Capitol.

Rome's work of benevolent assimilation was more thorough than the ravages of the Celtic hordes. The Latin conquerors took a measured third of the enemy's land, and ingeniously swindled him out of the remainder by the methods which white races now apply to colored. When the feat was accomplished they visited their contempt on the surviving natives of the conquered province, as being low-lived tradesmen. It is proverbial that the Etruscan merchants were very wealthy, and Etruscan clergymen very fat. An abundant religious literature survived the downfall of Etruria's independence for a century or so, before Latin courts, Latin schoolmasters and Latin corporals killed its very language. Etruscan works of magic and witchcraft, divination and astrology were consulted by Roman religionists. But the dead nation appears to have possessed few artistic forms, no written poetry. This is all the stranger, if we consider its proclivity for the best fruits of Greek artistry. Had the muse fanned the foreheads of Etruscan votaries ever so lightly, there would be snatches of song among the twelve thousand written records which the editors of the Etruscan *Corpus* have collected from tombstones and stone coffins, clay urns, painted catacombs and lead plates. But no. Our own village cemeteries yield a richer literary harvest. One wearies of this endless procession of the Etruscan dead, whose names and surnames and dignities flash out from hayricks of incomprehensible word stuff and are gone.

Whether we shall ever be regaled with a literary masterpiece in Etruscan is doubtful indeed, although over one hundred longish texts, in the aforesaid twelve thousand, must hold strange secrets. The curator of the museum of Agram, Croatia, captured, recognized and published the longest, in the nineties. He unwound it, unexpectedly enough, from the bandages of a female mummy which an Austrian tourist had acquired in Egypt about the middle of the last century. The text was alphabetic, and manifestly Etruscan. Its alien owner, stranded in Egypt, had evidently sold this "linen book" to an Egyptian embalmer for a song. This new prose text aroused no small interest in scholarly circles. But it, also, remained unread until yesterday.

Let us be frank. The Etruscan question, once a popular topic of learned speculations, discussion and prophecy, ended by becoming a bore. Judicious linguists abandoned it to the adept in craniology. Still, persons seeking knowledge of matters Etruscan were not left utterly resourceless. Jules Martha brought out two excellent illustrated manuals of Etruscan archeology, which the earnest reader could supplement by dipping into Dennis, Noel des Vergers, Gsell and the *Notizie degli scavi*. And one French scholar, this same Jules Martha, continued to break his head, privately, with the linguistic remnants, like the two German veterans whose quarrel and failure I recalled above. Nobody had much faith in the language side of his researches.

After twenty years of patient returns to the charge, Martha has at last broken silence. His paper on the right place of the lone nation, astray in southern Europe, was submitted to the Académie des Inscriptions in a January meeting this year, and was received with well-merited acclaim. I find his observations and conclusions repeated in the *Courrier des Etats Unis* from an article of M. André Beaunier's in the Paris *Figaro*. Were Martha's hypothesis to be demolished by a German or Italian shelling, it would not be the first time an epigraphist has been convicted of mare's-nesting. For to skate on the frozen waters of primeval ethnology is to skate on thin ice. But we owe this patient toiler in the linguistic vineyard no less than the present restatement of his novel view.

In default of a bilingual text, Martha's method, at the outset, was to neglect the etymological data. He gave all his attention, rather, to the order of words in a phrase, to the syntax of the unknown tongue under observation. He was presently able to distinguish subjects and predi-

cates, and nouns from the verbs. From their *desinences* he reconstructed stems and roots, like his predecessors, and with the aid of these, finally, the flow and rhythm, as it were, of a meaningless language. The next step was to find a corresponding grammatical lilt in other tongues, regardless of their nearness or remoteness to the Tuscan habitat. After diligent searching—since phenomena of this order are not very well indexed yet—Martha found the required grammatical analogies in the Ugro-Finnic tongues, a racial group which is now best represented in Europe by the Magyar or Hungarian dialects, and of course by Finnish. Since Martha is by no means the first scholar to read these languages, the reader would be hasty to infer that any Finn or Hungarian can understand the transcription of an Etruscan text at sight. The case is more like putting a contemporary Greek at reading one of the Cypriote inscriptions in the Metropolitan Museum, or a modern Arab at reading Himyaritic epitaphs. Martha's method has endured one severe test, however. His rendering of the Agram text discloses a manual of navigation in its mysterious leftward-running lines. Victor Bérard recently traced the incorporation of Phoenician sailing directions and navigators' logs in the Homeric Odyssey. The Agram *liber linteus* is a lost waif of the Etruscan admiralty publications, if one may employ this modern term.

Martha's translations of the epitaph literature carry us a little nearer, perhaps, to the soul of Etruria. "Tute was Larth, and now Tute is wretched." Here we have the sepulchral change of name. "He was a strong man, an accomplished man. Eight times he wore the bordered robe." The obituary notices of the future will doubtless celebrate the non-recall of American magistrates with similar unction. "But now he is nothing."

Ludwig Steub, a Bavarian alpinist, discovered the Etruscan derivations of innumerable Alpine place names, years ago. They lent support to his theory that the conquerors of northern and central Italy entered the peninsula through the Tyrolean passes. With Martha, we can now almost follow the Ugro-Finnic migration westward from the Ural Mountains to its tricuspid forking into Finland, Italy and Hungary. Here philology deserts us. But the archeological evidence continues to favor our recognition of another eastward push of the same race, which bore fruit in its settlement of southwestern Japan.

## A Decadent Sense

To THE fundamental principle of modern biology that any organ which is decreasingly used tends to degenerate and become rudimentary, is ascribed the modern decadence of the sense of smell in man, a subject discussed by H. Ahlenstiel in a late number of *Umschau*.

The business of life is no longer directed or determined by olfactory stimulation, as was frequently, if not always, the case in a more primitive era. "Nature herself values this sense so lightly that she allows such a general and insignificant malady as the 'cold in the head' to cripple it for longer or shorter periods. Man to-day is a creature of eye and ear. The olfactory sense is decadent.

"The modern man has in a very brief time lost the perception of many odors of which his ancestors were sensible. For example, the physicians of the middle ages could still recognize diseases by their odors, and according to Humboldt the Peruvian Indians could track game by the scent as well as hunting dogs. And to understand such curious phrases as 'In the odor of sanctity,' and 'To be in bad odor in the community,' we must conceive that formerly certain odors were perceptible in such instances."

Besides this *quantitative* loss Ahlenstiel finds there is a far more important *qualitative* loss, one evidence of which is inability to analyze the component elements of mixed odors, a defect comparable to that of an eye without a lens, in which case sensations of color and brightness are received, but clear outlines of objects are not perceived. Such an eye is manifestly imperfect, and so is such a nose, compared to that of the dog, with its power to analyze a mixture of odors and select and follow any given one as we can a definite optical stimulus.

A third evidence that the olfactory organ is degenerating consists in the speediness with which it becomes fatigued. Thus people quickly cease to be conscious of the perfume on their clothing and workmen in sewers soon become oblivious of the evil atmosphere about them.

"The sense of smell has nothing more to say to us; and since it would be purposeless and unbiologic for an empty sensation, incapable of yielding us data for vital conclusions, to make demands on the powers of attention, after a short time the door of the nose is closed to the stimulus which assails it; while the dog, on the other hand, is capable of tracking game by the faintest scent for hours without tiring, since his olfactory organ is intrusted with the vital function of detecting food supplies."

Smell is important to us now only in connection with the appetite, and in this case it is commonly confused with *taste*. But taste is really capable only of distinguishing the sensations of sweet, sour, bitter, and salty. All other flavors are really *smelt*, though with the difference that the stimuli do not come in the normal way, through the external nasal orifices, but from the vapors of the food rising through the oral passages in the rear of the nose.

The most interesting part of Ahlenstiel's article, however, deals with the singular power—often noted in history and literature—of olfactory stimuli to awaken vivid memories of past scenes and events. He explains this as follows: "When an odor which we have smelled for a time in a more or less important period of our lives—for example, the reek of the dungheaps during a stay in the country or the smell of the tarred boats in the harbor on a vacation trip—comes to us a long time after in a different place with the same intensity, we are at first conscious only of a familiar odor. But then nature begins to feel that a sensation which at one time played a not insignificant part in our lives can not be ignored, . . . and she opens before us all the doors of the past and presents a host of memories, questioning whether any among them is significant.

"This leads us to the query whether olfactory stimuli can be purposely assembled and grouped to awaken similar sensations by art, just as is done with optical stimuli in painting and the plastic arts, and with acoustic stimuli in music. In some measure this is actually practised and constitutes the art of perfumery. This is held somewhat in contempt through its one-sided development. Only the so-called fragrant substances are represented. That there are among these a series of delicate and delightful odors cannot be denied—nor can reproach be offered to the discreet use of a refined perfume. But the fact is overlooked that these 'fragrant substances' constitute only a small part of the odor-bearing products—even of those of agreeable odor.

"And there are not wanting signs that before long a much higher valuation will be set upon odors, and it looks as if people were beginning to prize the sensations proffered by various odoriferous substances besides the so-called 'fragrant' ones. To our grandparents the reek from automobiles, the smoke of locomotives, the iodoform aroma of the hospital, are still disagreeable, still banned by the taste of the last century—we, their descendants, no longer fear to love life itself as it is.

"It seems questionable, however, whether we are as yet far enough advanced to make use of the above mentioned relation between odors and memory, and by corresponding combinations—naturally modified individually—to evoke memories and moods from the Sea of the Past, and thus create, as it were, a sort of symphony of odors.

"But such a thing is by no means impossible; and if there are serious obstacles to it under normal conditions, on the other hand there is a condition—that of sleep—in which many of these vanish, and in which this experiment has been successfully tried. Thus Verworn tells us in his "Mechanism of the Psychical Life" (*Mechanik des Geisteslebens*) of an experiment—instituted, to be sure, to other ends—in which a perfume which he had brought from Egypt was held to the nose of a sleeper, whereupon he dreamed he was entering the booth in the Bazaar of Cairo, in which he had brought the perfume, etc. We have here, therefore, succeeded, though under abnormal conditions, in vividly reviving latent memories by stimulating the sense of smell."

# Electricity as a Factor in Civilization*

## Its Influence in Industry, Commerce, and in the Home

By Dr. J. Siegel

PHENOMENA that strike us as new and novel, things we meet for the first time, are apt to produce in us a certain feeling of awe, curiosity and surprise, at the same time of gratification. They first enter our existence as merely personal experience, manifesting themselves as sensations. Not until these feelings have died away is reflection added—that intellectual faculty by which we appreciate the value, or otherwise, of the new phenomenon, each of us at first only insofar as his own personality is concerned. It is only some considerable time afterwards, when novelty has given place to habit, that we begin to think of the importance the new fact is likely to have for the community. If in this connection we find it to be of importance for our life and to exert a favorable effect, we call it a "factor of civilization," thus meaning that the new fact assists us in satisfying our vital heads, permeating and ennobling them, with a less expenditure of energy and matter than had previously been possible.

May we in this sense term electricity a factor of civilization, may we assert that it permeates and ennobles our vital needs? Can we prove that electricity, more than any other means at our disposal, enables us to practise economy in the household of the individual, as well as in the household of the nation and the household of nature?

The existence of modern man fluctuates between work and leisure, between the hustle of business and the quiet of home life. What important part electricity is called upon to play in this connection, a superficial glance will show. You will doubtless agree with me in saying that a really exhaustive discussion of the influence of electricity on the form of our civilization is neither necessary nor possible in the short time at our disposal. Let it, therefore, suffice, in order to form an opinion, to discuss the fundamental importance of electricity in these fields and to examine a few typical instances. It is only as regards its domestic uses that electricity does not enjoy undisputed recognition; many a prejudice has yet to be overcome, many a distrust to be removed; before the importance of electricity in civilization becomes generally acknowledged in this field which perhaps touches us most closely.

Looking back we see the first important application of electricity in the field of transportation. Electrical telegraphy and later on telephony enabled us to solve the fundamental problem of inter-communication, the overcoming of time and space in a manner such as to satisfy the most optimistic dreams. The safety and rapidity in the transmission of news were thus improved to a degree unknown and hardly thought of, and as all civilization is based on co-operation, which in turn depends on an exchange of views and ideas as rapid as possible, we at once realize the cultural importance of electricity in this field. I have only to remind you of the marvelous rescue of ships in distress by wireless telegraphy, of the rapid and effective aid made possible by electricity in the case of great catastrophies or of the prompt and successful warnings and preventive measures in the approach of epidemics, to show how well electricity is capable of assisting the most primitive and original of all human instincts, that of self-preservation. So far, however, from being limited to this "defensive" part, it aids most actively in the development of active traffic.

The enormous condensation and increase of traffic produced by the adoption of steam power would not have been possible, had not electricity, by an accurate and rapid transmission of news as well as by other arrangements, such as electric lighting systems, electric loading plants, turn-tables, etc., improved at the same time the conditions under which this traffic is prepared, effected and ensured. Electricity announces the approach of trains and anticipates their departure; electricity controls the signals and regulates the shunts, guides the trains into their paths and bids them stop if there is any danger, in fact, electricity safeguards and controls the whole of traffic, and the fine network of wires it requires on its way has become its nervous system. However, in spite of the undoubted importance of a well-working nervous system for any living organism, this would be dead but for its heart and muscles, powerless without any driving force. Electricity has also been able to undertake this function—at first in tramway operation. Electric tramways more than any other means of communication combine speed and safety, frequency of trains and cheapness of travel. Other important factors are the central regulation (and accordingly high economy) in the production of power, the adaptability to the requirements of traffic, elimination of smoke, soot and dirt, economy of time and possibilities of an adequate separation between residential quarters and centers of business. The same reflections apply to the electrification of trunk railways:

* Abstract of a lecture delivered at the general meeting of the Society of Electricians, Berlin, on December 2d, 1911.

Concentration in power production and accordingly, lower working costs; the noise and dirt are reduced to a minimum, and the work of the personnel is limited to a few manipulations. The speed of travel and the frequency of trains can be increased, and the comfort of travel enhanced; in fact, electricity, more than any other agent, ministers to the satisfaction of our wants with a less expenditure of material, force, and energy.

However, in spite of its undoubtedly important rôle in modern civilization, traffic only fulfils intermediary functions, creating no new values intellectual or material. In order to appreciate the cultural value of electricity we should, therefore, attach more importance to an investigation whether electricity has penetrated and transformed not only the means of communication, but the whole professional life, agriculture as well as industry, commerce and trade, art and science, creating new values everywhere.

To agriculture electricity has proved a boon, eliminating the drawbacks connected with the scarcity of manual labor. Electricity has, in fact, not only yielded a cheap, convenient, and safe means of lighting, but in the electro-motor, supplied an agent working more reliably, rapidly and cheaply than man or animals, which has given rise to the construction and adoption of small and light machinery.

The extent to which electricity now controls agriculture can be inferred from the use of electrical machinery for many operations which had previously been done exclusively by manual labor with a considerable expenditure of time and energy. The adoption of electrical sheep-shearing machines, has, for instance, increased six-fold the output of each operator, while reducing to one sixth the time required for a process so irksome to the animal. Milking is now done mechanically by electric means, thus sparing the animal and insuring a cleanliness and hygienical operation hitherto impossible.

If electricity in these fields has been a useful helpmate, it has become a mighty ruler in the realm of industry and trade. The concentration in the production of energy, simplicity of power transmission and possibility of power distribution down to the smallest units have made possible this victorious career of electricity. The impetuous winds are harnessed to perform regular duty, the sun's heat stored in coal for thousands of years is converted into brilliant light, creative energy, useful warmth; rushing waterfalls are compelled to convert their roaring violence into indefatigable work spent in useful activity, and the very motion of the tide is subjected to its power. Electricty then sends out its servants, through slender wires into towns and villages, houses and yards, factories and laboratories, wherever they may be required.

The present tendencies of specialization and production on a large scale in a series of successive stages have been promoted by electricity, while the reduction in the cost of operation, elimination of manual labor, improvement in the social and hygienical condition of all branches of industry have brought about more powerful developments than had ever been witnessed in so short a time in any field of human activity.

Nor is the electric motor less important to the artisan than to industrial workmen. Many branches of the small industries, which, in view of the powerful development of factories were rapidly nearing extinction, the electro-motor has again placed on a working basis, so that they are able now to keep their own. Whereas tailors employed in wholesale production formerly delivered at most eight suits per week, electrically operated cutters, electrically driven sewing machines, and electric flat-irons now enable them to earn many times

Sealing Letters by Electricity.

more than previously with less physical exertion and in healthier surroundings.

Bakers have provided for our increased hygienical and social requirements and for the general tendancy towards a better utilization of energy, by adopting electrically driven kneading machines. The carpenter, instead of transporting heavy logs into his workshop with a considerable expenditure of time and wages, or working them laboriously by hand on the spot, is now enabled by means of portable electric drills to perform his work on the building site much more rapidly, conveniently and satisfactorily. The same kind of remark applies to butchers, locksmiths, joiners, in fact, there is no artisan who could not advantageously replace human labor by electric motors, while increasing the output, improving his sanitary and social conditions, and thus raising the standard of his art.

After this appreciation of the influence of electricity on modern industry, we should similarly acknowledge its importance in the field of commerce. All progress achieved by electricity in connection with traffic (by a safe and rapid transmission of news and a considerable acceleration and simplification in the transport of passengers and goods) are, in fact, of the same importance to commerce. The enormous extension, the increase in the volume of business and the simplification of transactions would not have been possible without the aid of telegraphy or telephony.

Less striking, though of no smaller importance, is the function of electricity in the realm of science. Apart from its own intrinsic interest as a separate branch of science, it has stimulated and led to successful work its older sister sciences, expanding the realm of chemistry and physics, endowing them with new means of observation and more efficient arms, and thus preparing new and important results. Thus, for instance, the discovery of electro-magnetic waves has resulted in the development of wireless telegraphy; then we have such special branches as electro-chemistry, the determination of high speeds and high temperatures, etc. Electricity has furnished the mathematician with new problems, and the lawyer with new tasks. Electricity has not only supplied medical men with new means of diagnosis (X-rays, etc.), but has done direct service in the cure or relief of many complaints.

As in all phases of our daily work electricity is our faithful companion in our leisure time, also telephones have become an all-important factor in our social life, and the modern theater without electricity would be unthinkable. Electricity not only affords safety against fire, but yields a most effective aid to the whole technical service of theaters. The brilliant effects of light and decoration which excite our admiration have been created by electricity, and a new and important theatrical branch, the moving picture show, is indebted to electricity for its very existence.

There is only one important realm of the human activity which is not closely connected with electricity, that of fine arts. It is true that electrical industry has resorted to art in improving its products and that the mutual effects between architecture and electric lighting are becoming more and more intimate.

Among the manifold applications of electricity probably its domestic uses are least appreciated, though the most various electric machines calculated to facilitate household duties have been designed of late years. Not to mention electric lighting and heating, there is the electric kitchen with its manifold advantages. There is the electrically operated vacuum cleaner, electrical flat irons, knife polishers, laundry machines, sewing machines, bread slicers, and many other devices increasing the comfort of our home.

These manifold minor applications of electricity are by no means useless refinements of civilization or manifestations of an undesirable luxury. Each one of them is, in fact, connected with a saving of time, force and energy, and accordingly with an increase in well-being, enabling us more joyfully to do our work and to face more effectually the struggle for life. In fact, the tendency for comfort promoted by the uses of electricity has been a factor of enormous cultural importance in the history of mankind, as those improving their standard and fulfilling their task more speedily are more valuable members of society than those wasting their energy in trifles and performing their work only reluctantly.

Wherever electricity has been adopted, there has been increased safety and efficiency, with less expenditure of material and a substitution of mechanical labor for human and animal muscular work. There is thus an increasing spiritualization of labor which, commenced by the steam engine, has been promoted more and more by electricity, and we must expect this tendency to extend even farther in the future.

Electric Shearing Saves Labor and Spares the Sheep.

Hot Air Douche for Drying the Poodle After His Bath.

Fig. 1.—Battery of Granite Saw Blades in Position.

Fig. 2.—The Inner and Outer Frame Work of the Granite Saw.

# A Machine for Sawing Granite

## A Most Useful Adjunct in the New England Quarries

By Frank C. Perkins

Among the large and numerous granite quarries of New England, where the operation of quarrying and cutting of some of the hardest known granites has become one of her leading industries, a most interesting machine is used for sawing and saving the granite. The accompanying illustrations, Figs. 1 to 4, show the details of construction of this device, while Figs. 5 and 6 indicate the work that it accomplishes.

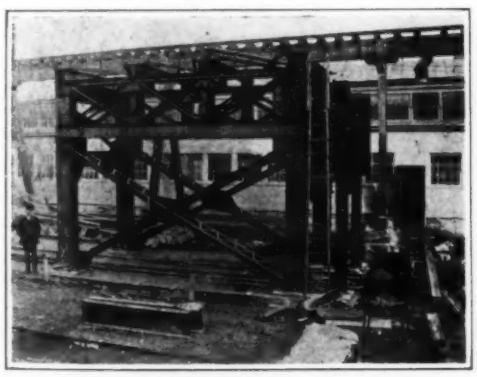


Fig. 3.—The Outer Framework.

The advent of the machine in these eastern localities has proven of great value to the granite trade in turning out surfaces so smooth and straight that the cost of bushing a sawed surface to a finish is reduced to less than four cents per square foot. At the same time the waste stone is diminished to the smallest amount possible, the machine producing many times more square feet of surface per day than has ever been done heretofore.

The advantages obtained by the use of this machine are many. Among these is the ability to saw any length of stone, such as spire and roof stones for vaults. Owing to the construction of the cars and their clamping devices, small stones can be sawed as well as large ones at no great additional cost, thus making it very practical for use in many quarries where large saw blocks are not obtainable.

In building work there is usually one side of the material exposed, but by the use of the monocut of this saw there is no sawed surface or stone wasted, as the blocks are quarried large enough to make two stones by sawing through the middle. This method puts a surface on each stone for exposure and with no waste sawing, as is the custom with gang saws which make four or more cuts in large blocks and which produce slabs with two sawed surfaces, where with others only one finished surface is necessary.

The saw is constructed of structural steel, the length of the outside frame being from 23 to 33 feet and the width 11 to 18 feet, while the height measures 18 feet. The outside frame is made of very heavy steel and of very rigid weights ranging from 25 to 30 tons. This frame is set on concrete foundations and securely bolted thereto. The inside frame is also of structural steel and weighs from 8 to 12 tons. This is hinged or pivoted to the rear columns of the outside frame and the height of either end can be varied at will to accommodate the depth of stone going through the saw. The operation of raising and lowering either end of the inside frame and therewith the blades is done simultaneously with the cutting without stopping the machine. By the universal adjustment of this frame which carries the cutting blades, the greatest uniformity of cutting can be maintained and approximately the same amount of square feet of sawed surface can be produced per hour whether operating in stone measuring 2 feet or 5 feet. The head shafts, heads and cutting blades with their adjustment rods are suspended from the under side of the inside frame. Each head is pivoted on its individual cross shaft, held in journals. It carries at its lower extremity a steel cutting blade, and the cutting ends of the blades oscillate through an arc of approximately 2 feet 3 inches. These heads and blades are so proportioned that they cut a series of intersecting arcs, each blade cutting its own separate arc and each arc lapping into those of the next

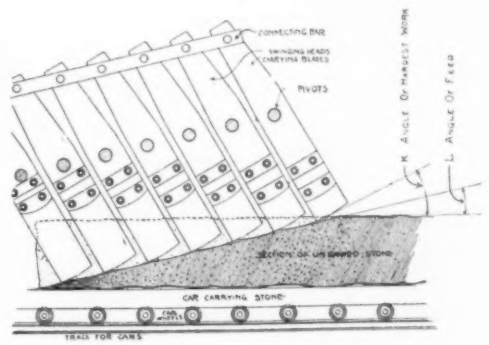



Fig. 4.—The Saw Blades and Their Pivots.

adjacent blade both fore and aft. The front or shortest blade cuts a channel straight along the top of the stone, and the remaining blades follow in this channel, each cutting its proportionate amount deeper until the last blade cuts completely through the stone.

This arrangement breaks up the straight line cut on the edge of a long, thin blade, held at its ends and forces the abrasive material to pass down by the sides of the blades before coming to its cutting position (as in gang saws) into a series of circular cuts

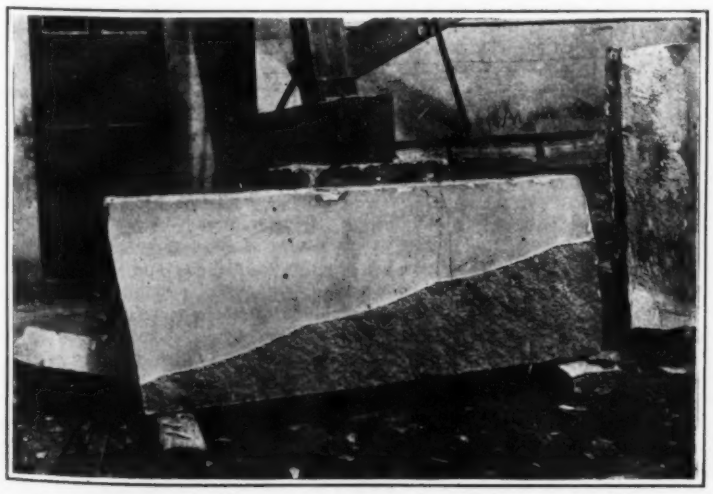


Fig. 5.—Granite Block Broken in Two After Having Been Partially Sawed Through.

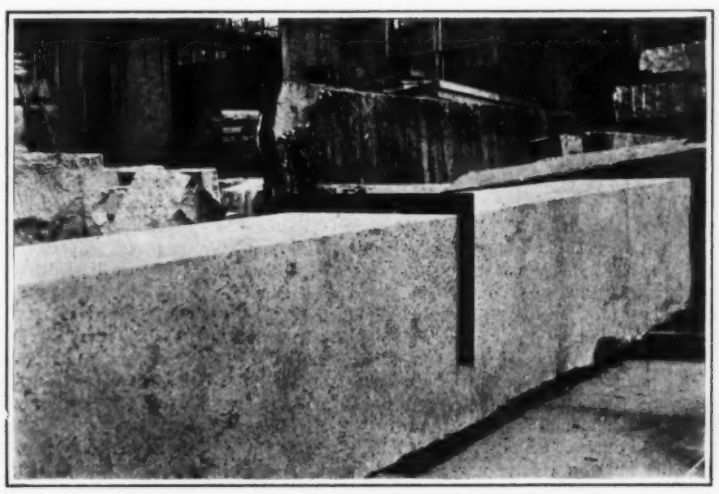


Fig. 6.—A Long Granite Beam With Two Faces Finished by the Saw.

on the ends or points of the several individual blades where the abrasive material advances from one cut to the next, and is thus fed automatically at each stroke, directly under the cutting ends of the blades without passing by the sides.

It will be noticed that the heads, carrying each an individual cutting blade, are all united by a parallel bar connecting rod at the top and that they swing simultaneously through their several arcs. The connecting rod is driven from a crank on the main shaft by a pitman arm connection. The cutting is accomplished by the use of chilled steel shot under the cutting blades.

The shot, with sufficient water, is fed into the cut around the first leading blades and follows from arc to arc and blade to blade down the incline during the swing of the blades through the stone, the shot and muck finally passing out of the cut and away from the stone at the rear end, and after the shot has served its purpose of cutting under each and every blade in turn. The process of cutting is, therefore, a crushing one produced by the rolling of the steel shot into the stone under the ends of the blades. The shot at the same time serves as a roller bearing or lubricant to facilitate the rapid and free movement of the blades against the stone. The blades are lowered to compensate for the wear, and when worn too short for further use in their several original positions are moved forward, each blade thus serving in each position consecutively from the rear, where they are 7 feet 6 inches long, to the front, at a length of only 2 feet 6 inches.

This machine in principle is practically an oscillating drill, where the cutting power is applied directly to the point of the cutting tool or the blade, in a straight line between the point of application (pivoted head shaft) and the point of resistance (the stone being cut) and similar in directness to the hammer and chisel in the hands of the stone cutter. This principle of application of power differs essentially from that of the gang saw where the cutting force is applied to the ends of long blades and through them, by their longitudinal edges, to the stone, thus passing the force through two right angles before reaching the surface to be cut instead of applying it direct.

On account of this improved application of power the saw produces an average of 10 surface feet per horse-power per day, where the usual practice under former methods rendered not more than 2 surface feet. The saw blocks of stone are quarried as large as possible and loaded upon cars 15 feet long by 4 feet 8 inches wide, each supported on twelve chilled cast iron trucks or wheels which run on a track aligned longitudinally with the blades. These cars are guided in their passage through the saw by head guides and shoes applied to the ball of the rail and assures the absolutely straight cut into and through the stone. The loaded cars are drawn through the machine by a screw 25 feet long, 4 inches in diameter, and 1 inch pitch placed between the rails operated by a variable speed drive and chain of gears, and can be passed by the blades at constant speeds varying from ½ inch to 5 inches per minute, according to the height and hardness of the stone being sawn. As each individual blade has its proportion of cutting to do, it follows that a 9-blade saw going through stone 2 feet high, each blade would cut a kerf of 2 2/3 inch depth only, while in stone 4 feet thick or high each blade would cut a channel 5 1/3 inches deep.

A stone 2 feet high passing the saw at 4 inches per minute would be cut at the rate of 40 square feet of cut or 80 square feet of cut surface per hour, while stone 4 feet high of the same grade would pass the saw at 2 inches per minute and the resulting amount of cut stone would remain the same. This saw will operate on any length of stone that can be quarried, the cars being so dove-tailed that the joints between the stones need not coincide with those of the cars, and a stone may extend over one, two or three cars if desired, the lengths of the piece being limited only by the capacity of the quarry.

When a stone and its supporting cars have passed the saw the car is unloaded, raised from the track by the attending derrick or crane and returned to the front of the machine, to be again reloaded with stone and connected to the car immediately preceding it. The operation of feeding the stone to the saw is continuous and the machine may be run constantly throughout the 24 hours, stopping only about every one hundredth hour to replace worn blades. The floor of the space occupied by the machine is concreted and channeled to facilitate the collection of the shot and the drainage of the muck.

The length of stone to be sawed is limited only by the capacity of the quarry to produce long stone. It is first loaded on cars and advanced forward to the blades by means of a screw (35 feet long) which is constantly pulling the car through the machine, thus enabling the saw to make a continuous operation. All that is necessary is to keep the stone loaded on cars in front of the saw; then as the car emerges from the back end of the saw the stone is cut in two, and the car unloaded, replaced in front of the saw and reloaded. The fact that all cuts are on a slight incline is a great advantage over the gang due to the fact that during the operation of sawing the saw is constantly washing the mud out of the cut and keeping each blade well supplied with shot. Each blade cuts an independent surface of its own, and on account of the difference in the wear of each piece of steel, one piece may wear off faster than the other. When this occurs, the next following blade has a trifle more cutting than the adjoining blades, and it is unnecessary to stop to adjust the blades. With the arrangement of the blades it will be observed that as the blade becomes too short from wear to cut through the stone it is taken out, the other blades moved up, one head and a new rear blade put in, making the last blade eventually the first.

Regarding the construction of heads and blades, it is found that the principal reason for this special construction and arrangement of the blades cutting an arc is to break up the cut of the gang saw which was a straight line cut, and in order to overcome the old method this saw is arranged with heads and blades in alignment so that one is longer than the other, from the front to the rear, and pivoted at their central points so that all swing simultaneously as shown in the diagram, making one cut on an incline. By this method of operation the cut is made up of intersecting arcs as there presented, where $K$ is the angle of hardest work for these blades and $L$ is the angle line of feed.

# The Irrationality of War*

## Science as an Element in the Developing of International Good Will and Understanding

By Sir Oliver Lodge, F.R.S., O.M.

HUMANITY is a race of workers, and on its output of energy the well being of the planet now largely depends. The work of the human race is directed toward

(1) Sustenance,

(2) Advancement;

and on the whole the work is conducted at high pressure and there is little margin to spare. The more energy that has to be expended on mere existence the less is available for progress and development. Consequently it is in moderately fertile countries and peaceful times that the greatest steps in Art and Science have been made. When existence is threatened there is neither time nor opportunity for advance.

Humanity works in sections, and it is possible for these sections to quarrel and to seek to injure or destroy each other; thereby interfering with each other's bare subsistence, and taking attention off higher things. It is notorious that in such disputes much energy can be unprofitably consumed, or, more accurately, degraded; and also that even if there is no active quarrel between two sections, still the possibility of it entails severe preparation and anxiety and much unprofitable caution and disabling fear. So it used to be at one time between families, then between tribes, and now between nations; yet the sub-division of the Race into nations, with differing facilities and a variety of customs and traditions, ought to have a beneficient influence as well as add greatly to the interest of life. So long as the sections co-operate and mutually help each other, all is well: each benefits by the discoveries and advances of the rest, and a valuable spirit of Emulation is aroused. But when emulation degenerates from wholesome rivalry into a spirit of envy, hatred, malice, and all uncharitableness, so that the sections wage an internecine conflict, then the warring among the members is a calamitous evil, and humanity as a whole is bound to suffer.

### SCIENCE A COSMOPOLITAN ENTERPRISE.

In some departments of civilized life the risk of unwholesome and mutually destructive contest is more rife than in others. Certain fields of labor there are in which the spirit of rivalry never now degenerates into hostility and mistrust. These are the cosmopolitan enterprises and labor to which every nation can contribute, and in the results of which every nation can share. Of all these cosmopolitan efforts those included under the general head Science are among the chief. Literature is more of a National product, the literature of one nation necessarily appeals less forcibly to another nation; alien language is a bar to complete enjoyment. But scientific discovery can be made at once interesting, can be assimilated and its fruits reaped by all. Any discovery made by a group or by an individual becomes thereafter the property of humanity, and the world is advanced a step higher. And, short of catastrophe, such a discovery is made forever; it is not liable to decay like a picture or a statue; it is in the spirit, so to speak, it is not incarnate. Many discoveries are not only world wide but cosmic, and if ever we are able to communicate with another planet they could be appreciated there too. This is especially the case in such subjects as Mathematics, Physics, and Chemistry, and is probably true of a great part of Biology also. These great fundamental sciences are cosmic in their scope and significance. These and all other sciences are at least international. Science tends to weld the nations together; and even though petty jealousies and personal rivalries exist for a time, they seldom survive a generation; they are felt to be unworthy and unseemly, and the successful worker sooner or later meets with a world-wide appreciation.

### THE LABOR AND PROBLEMS OF PEACE TIMES.

But it needs all the energy, all the spirit, all the encouragement that can be given, to pursue this work; the labor of peace times is indeed strenuous, the problems to be solved demand the keenest intelligence, the most indomitable patience; and they represent a strain on the highest powers of a nation. To produce a Helmholtz or a Kelvin is a demand on national vigor—a feeble nation cannot as a rule produce great men. Appreciation also is necessary, and appreciation from other nations is especially welcome and is usually forthcoming; it is a sign and token of civilization when such is the case; and the fact of appreciation reacts with especial benefit and stimulus on the otherwise solitary worker. For such a man must be in advance of his contemporaries, and yet must not be too hopelessly and utterly beyond the appreciation of them all; the career of a great genius becomes well nigh impossible when the general standard is low. To cultivate science therefore demands high qualities and strong character; it is a task of difficulty; whereas to rush into a quarrel and fight is easy enough. A savage in this art is an adept. No demand is made on self-control, no lofty national spirit is needed in order to fall into a misunderstanding or to feel the pangs of envy and of greed. And yet it is in the encouragement of this facile mood that the greatest national enthusiasm and Patriotism are felt, merely because the condition recurs at intervals, like an appetite; whereas the steady strain of work for the common good excites no enthusiasm, calls forth no encouragement, and but little recognition or praise. Smooth indeed is the path to a quarrel, easy is the descent to war, night and day the gates stand open; but to take up again the works of peace, to climb the step ascent of Science, that is the burden, that the toil.

### ANCIENT AND MODERN WARFARE.

Nevertheless it is often claimed that high qualities are demanded by modern warfare; and the claim is well founded. Qualities of mind and body are indeed evoked by it, and the nobler the nature the more can it respond to the demand, when the special call comes. That is what is asserted, and that is surely true; but this is only one aspect of the universal struggle for existence, it is a natural result of all corporate effort towards a common end: such qualities should be called out by every kind of emulation between nations; and would be, if only the pressure were occasional and episodical instead of constant and steady. Use and wont seem to blunt the feelings, and sap the energy of the average man. But it is not a different set of qualities that are needed in war, it is the same qualities raised to incandescence by the momentary burst of national feeling. For how are high faculties stimulated by war? Not by the mere killing—the killing is an episode, almost an accident; the actual fighting is a small part of a campaign. The rage to kill may have a survival value, but it is rapidly becoming obsolete: there is no real lust of slaughter in modern warfare. it is regarded as a grim inevitable necessity. Modern fighting is mostly done by machinery—especially naval

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fighting. No personal animosity lies behind it; skill and prowess are evoked, but it is engineering skill and the prowess born of peaceful practice and essays of sport. The effort is akin to those which lead to success in games. One essential element of ancient human warfare is absent from any modern battle; there is no hate, often no vision, of the foe. Triggers are pulled, or guns fired, and unseen distant men drop; and this may continue till a battle is won, but the triumph is due to the inventive skill that has devised the instruments and the organization that has brought them to the right place at the right time. Modern warfare is a great organization—a great industrial organization—it involves transport, complex machinery, supplies of food and clothing, and many another peace necessity. All these arrangements and faculties and powers are called for and trained and developed in times of peace. Wars are not now won, as they used to be, by extermination, but by successful management and organization; and ultimate victory is largely dependent on the pertinacious power of the purse. It was not so in old times, when men fought face to face and used their muscles to give blows. Then the feelings cultivated by Christianity were in abeyance, then the wounded were slain, non-combatants were rigorously dealt with; then there might be war to extermination. Those were the logical and rational times, so far as war is concerned. Killing was a savage business, and was appropriately conducted in a savage manner. Now the whole outlook has changed, and the rationality of war has departed; we fight by machinery and industrial organization. Scientific ingenuity devises constantly new apparatus, and skilled manufacturers execute it. A battle ship is a scientific laboratory. Thus Science is applied to an alien use—a use which would have to be stigmatized as unholy were it not that in the present unhappy state of European civilization these things are essential to defence.

The power to produce ingenious things and use them is excellent: the gratuitous bringing about of catastrophes by their means is diabolic. That is what war does: it brings about, on purpose, disasters which in peace we regard with special abhorrence—destruction of crops, railway accidents, shipwrecks, explosions, wounds, and violent deaths. The nations are naturally horrified at what they are doing, even while they are still at war; and they send surgeons and nurses to repair the damage done, even to the enemy, as quickly and as painlessly as possible.

### OPPORTUNITIES FOR PEACEFUL EMULATION.

Then why should we continue our rivalry into this illogical and brutal extremity? The only excuse that can be made is that our ancestors did it. But our ancestors had no other way of competing; practically they only came into contact with foreign nations for the sake of bloodshed and plunder. But engineering progress has made travel and international intercourse easy, and we can go abroad now with more facility than they could then travel across England. Language is still a barrier, and is responsible for many misunderstandings, but in all essentials it is easy now to be on friendly terms with every civilized nations. We trade together, we study the same problems, and encounter the same natural difficulties. In thousands of ways, we can help each other, in one way and one way alone can we do each other serious damage. Exertion is good, and fighting is strenuous exertion, but why not fight now solely by means of organization and enterprise and scientific skill and ingenuity? Why not show emulation and high spirit in the various industries and arts of peace? Why destroy and ravage the property of humanity? Why should one section seek to destroy another, when all can co-operate together for the common good, and when all are members of a common brotherhood, so that if one is injured all suffer? Why not give to humanity the benefit of the whole combined enterprise and the conjoined cultivated skill; why not discourage the artificially-fostered and quite impersonal hate, and omit the too successful and unmeaning butchery? If the end sought were extermination, war would be intelligible, though in these days of mutual interests and commerce, to kill off your customers is surely unwise. But when the nations are working hand in hand in scientific discovery and invention, as well as in Arts and Crafts of every kind, when they recognize each other's good work with real enthusiasm, and hand each other medals and dine together and feel friendly and rejoice in each other's progress—then suddenly to reverse this attitude, at the bidding of a few frenzied newspaper writers, and convert the weapons which scientific investigation has made possible into engines of desolation and slaughter—that is monstrous and detestable.

### THE BROTHERHOOD OF SCIENCE.

Fortunately there is hope in the prospect before us; the craftsmen of every land are finding out that their interests are common, they are beginning to realize that it is madness to seek to destroy and ruin each other. The educated people, and especially the men of Science, have long known this. By interchange of periodicals, by frequent international visits, by the action of great societies, and by making use everywhere of all knowledge wherever it be acquired, they have long practically realized the solidarity of humanity; and, in spite of such political hostilities as are forced upon their notice, their attitude to all co-workers is necessarily and essentially one of fellow feeling, sympathy, mutual admiration, and brotherhood. No warlike enthusiasm is needed, no alien excitement is called for, to break the monotony of scientific work. In work such as this there is no monotony: excitement and thrill are provided by the prospect of a discovery. There is plenty of room also for effort and strenuous exertion. There are dangers too to be encountered, dangers of disease and accident—witness the self-sacrifice of many an investigator, whether he be a geographical explorer, or an X-ray worker, or a student of tropical disease. There is very little monotonous toil, though there is much steady work. An eruption of barbarism would be no relief, it would be a discord, a painful interruption.

It is the deadly monotony of the ordinary life of the multitude that constitutes a civic, a national, danger. It is this that drives people to drink and unworthy relaxation. It is this that makes people welcome the feverish excitement of a catastrophe or of the imminence of war. It is this which is responsible for much of the gambling that goes on. The deadly monotony must be broken, daily life must be made more interesting, work more joyous, human nature must be given a fair chance of equable development. The nation which first realizes the magnitude of the opportunity afforded by earth existence, and the responsibility resting upon those who co-operatively waste it in the mere apparatus and material of bodily life, the nation which by social reform liberates the spirit of humanity—that nation will arouse in its citizens a fervor of patriotism hitherto unknown, and to it will belong, not by military conquest, but by divine right, the supremacy of the future and the gratitude of the human race.

## The Psychology of Efficiency in Work*

By H. L. HOLLINGWORTH, Psychological Department, Columbia University.

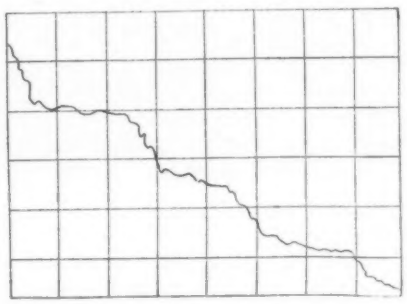
THERE are two kinds of work with which we can experiment. The first is the kind of work one does in learning a new performance. That is a characteristic kind of performance, and if you make a chart of your performance, speed, accuracy of the quality or amount performed, you will get a characteristic curve showing the progress of your work, and there will be certain things found true of that kind of work.

The other kind of work is the kind one does after a performance has been perfected. There also you get "curve." You cannot say anything about the psychology of work unless you have a measure. So we plot, in the first instance, what we call the "practice curve," and in the second, what we call the "fatigue curve." The present article is restricted to the discussion of some phenomena observed in connection with the practice work.

In any kind of performance you will have a certain curve different from someone else. Generally, practice is rapid at first, then slower. The greatest amount of practice comes at first. Another striking thing about practice curves is that they are irregular. It is impossible for the human organism to perfect itself. One day you do well, and the next day you may probably do worse. But that does not mean that you are not improving, because the following day you may do still better.

An additional point that has been found in experiment in practice curves is the presence of critical points, or "plateaus." This is much the same curve as is found when one learns the telegraphic language. The curve falls, and then it strikes a plateau, with apparently no improvement. But in some instances, if a man continues that plateau, he takes a sudden drop (which represents improvement); going down quite rapidly until he strikes another plateau and for some time runs along more or less on a level with few variations. So you may find two or three of those plateaus in the process of perfecting any motor or mental performance.

Experiments show that plateaus may mean either two or three things. In the first place, merely slumps in interest. You may begin to learn the typewriter to-day and keep up your interest a certain time—then the novelty of the performance is gone. In that case you never move from your level until you get new interest. And usually, the plateau is the point in the curve at which you learn the most, and that is the curious thing about it. In the typical practice test, what is taking place during this plateau is that you are acquiring habits you have not perfected, but which when perfected will bring a striking improvement.



A Typical "Practice Curve."

The start is at the left, and the descending line means *increased* efficiency. The "plateaus" are the three more or less level spaces shown on the line.

If you learn telegraphy you send letter by letter, and you increase, of course, up to a certain point, and then you cannot send any faster by the letter method. Then you are no longer improving. But if you keep up your effort during the plateau, there will come sudden increased efficiency, or a new plateau. During the formation of the plateau you are gradually acquiring your habit, but you cannot use your whole habit until it is perfected, and then away you go again and you strike another plateau, which is the physiological limit for work of that kind. The same is true of any kind of work.

The next important thing in the psychology of work is that the plateau is the point where, if effort is spent, you acquire a higher kind of habit, and improvement comes if you continue; the important thing being that it is only when the work is done with effort and with the determination to improve that that happens. Many a man strikes his plateau and runs for a month without any improvement, and then decides he has reached his physiological limit. He continues doing as well, but he lacks the determination to improve, and he will always continue throughout his life on that level. All that is necessary is the determination to improve, and persistent effort.

You will find it the most stimulating thing to keep your practice curve, measure your performances, and keep it on the chart. You will know how rapidly, how uniformly you are improving. You will know on what days you are improving, and in addition, there is all the fun of competing with yourself. The moment you see a plateau beginning you know now is the time to make unusual effort.

The practice curve has been used in the school room—in Germany—and it has been found one of the most useful pedagogical devices. I know of no device better calculated to improve a man's efficiency, either in thinking or muscular performances than keeping his own practice curves, and almost anything you do will admit of keeping a practice curve—addressing envelopes, stamping letters, walking to the street car, and so forth. Any conceivable thing can be measured in units of time, in number of words, etc. It should be most useful in offices and factories, to apply science in the interest of greater efficiency. The time is undoubtedly coming when business will eliminate guesswork and rule of thumb by the use of such charts in analyzing work of various kinds.

Another point in practice work is the pleasure theory of learning. In acquiring a new performance, only those movements are remembered which give you pleasure, or satisfy. If you are learning to play tennis and you want to send the ball in a certain curve of the court, once make the right movement, and you remember it, and the next day you will make it more quickly, and the next even more quickly, and so on. If a piece of work is accompanied by an agreeable feeling, it tends to be remembered, but if accompanied by a disagreeable feeling, it tends to drop out, and the general rule is that the disagreeable memory or experience tends to be forgotten. Nature is provided with that sort of mechanism—we push out of our consciousness that which we do not want to remember.

That principle is true of every simple movement. Suppose you are learning the violin. If you do not get satisfaction when you make the right movement, you will not learn. You will only learn to play when you get a real satisfaction from the sensation, and the man who practises in a perfunctory way, getting no glow of pleasure from successful performance, will not improve. It stands out even with animals. It is only when the animal is petted that he remembers his tricks.

*Reprinted from *The Efficiency Magazine.*

# Incubation Method of Ripening Dates

## Assisting Nature by Laboratory Methods

By Silas P. Markham

THE illustration presented on this page shows a fruiting date palm in the Salt River Valley, Arizona, which will ripen about 200 pounds of dates, while the photographs on the next page show the experimental apparatus for ripening dates by incubation and a sample of ripened dates packed for shipment. The writer is indebted to George F. Freeman, plant breeder of the experimental station at Tuscon, Arizona, of the University of Arizona, for the accompanying photographs and data.

He states that under the stimulus of this new process of ripening, many of the farmers of Southern Arizona are planting considerable areas to the date palm.

About a decade ago the United States Department of Agriculture sent a large consignment of the choicest of varieties of dates to Arizona, where they were planted and subsequently cared for at Tempe by the Arizona Agricultural Experimental Station. Many of the 200 varieties of dates there growing have ripened and are of varying degrees of promise commercially.

The most valuable variety of all, however, the famous Deglet Noor, which in the Arabian language means "the date of light," has never yet ripened satisfactorily in this climate, because the summers, though hot, are not long enough for the ripening process to become complete. The science and art of ripening the fruits has, therefore, been a subject of study by different members of the staff of the Arizona Experimental Station for years past.

Dr. A. E. Vinson found that the ripening process was due to the action of certain ferments called enzymes which, while the fruit is still unripe, are locked up in the cell contents of the growing dates. When the cells mature naturally, however, or are killed by heat, enzymes are released and become active, forming those substances which contribute to the flavor, aroma, and appearance of ripe dates.

Hot water, vinegar, gasoline and a score or more of other substances have been found to ripen dates artificially. Of these substances, vinegar or acetic acid was found best suited for practical work and by its proper use perfect commercial products were produced from many varieties.

Nature, however, often prefers the simplest means to accomplish her most perfect results, and it remained for Prof. G. F. Freeman, by exposing the partly ripened Deglet Noor dates from the orchard to just the right degree of heat and moisture in an incubator, to turn out dates that rival those sold on the Paris market from the African Sahara.

In this process the dates are picked when they show the first signs of natural ripening. After being washed they are placed in an oven where they are kept in a moist atmosphere at a temperature between 45 and 50 deg. Cent. for about three days. By this time they have become fully ripened, are moist, partially shrunken and very sweet. The same process is used in treating dates which have been allowed to remain too long on the palm, becoming dry and withered, except that they are soaked in water for six hours before going to the oven. When ripe the dates are packed in attractive little boxes, lined with wax paper having a lace border. The whole package is then wrapped in white moiré paper and tied with a ribbon after the fashion of candy boxes. These packages, whether open or closed, make an attractive exhibit and serve as an appropriate covering for the luscious fruit which they contain and on the whole make a product which is appreciated and readily accepted by the trade at prices which will yield 30 to 50 cents a pound for the dates.

Trial shipments have shown that dates ripened and packed as above described will reach the following widely scattered points in first-class condition: Seattle, Wash., Fargo, N. Da., Chicago, Ill., New York, N. Y., Washington, D. C., and Paris, France. All of the recipients of these packages were highly pleased and many expressed the opinion that the quality exceeded that of the best imported product with which they were acquainted. There is no doubt that dates artificially ripened and packed in Arizona will have a commercial range including the whole of North America.

Aside from the above noted trial shipment, the bulk of the crop has been sold on a single limited market, for the purpose of learning whether the initial ready sales were due to the novelty of the product and whether these dates are of such quality as would produce a steady and consistent trade in one locality.

Results so far have been gratifying and when considered in connection with the wide range of market which the shipping qualities of these dates make possible, they indicate that there is little danger of overproduction in the limited area of Southern Arizona and California in which this fruit may be grown.

Of course, only the finest dates go into the confectionary boxes. Those which are a little less desirable are pressed into bricks and wrapped in stout tissue paper. Experimental sales show that the trade will take these block dates at 25 cents a pound in preference to the imported bulk date at 20 cents. Moreover, clerks in grocery stores where both kinds are sold will push the block dates rather than the imported bulk dates for the reason that sales can be made without soiling the hands.

Another reason for the better sale of the pressed dates in small, neat packages is that in addition to the fact of a more sanitary packing and handling than can be claimed for the imported product, their cleanly appearance of itself is not without weight in the mind of the customer.

On the strength of the evidences above outlined it

This Palm Will Ripen About 200 Pounds of Dates.

may be stated that even the choicest of the old world dates may be grown and satisfactorily ripened in Arizona.

Because of the fact that date palms thrive on alkali land, incapable of producing other crops, Prof. Freeman forsees a great future for the industry now that a method of ripening the fruit inexpensively has been found. It has been proved, he states, by the date orchard at the experiment farm near Tempe that the Deglet Noor palm will produce 250 pounds of dates to the palm, with the palms planted 50 to the acre. This, with a yield of even 200 pounds to the palm, will make a yield per acre of 10,000 pounds.

He figures that as a commercial proposition, the grower will realize 10 cents per pound from the dates, and that the middleman, who ripens and packs them, will sell them for 20 cents a pound. At that rate the grower will make $1,000 per acre, gross profit.

The process requires only that the partly ripe dates be placed in pans in a room or chamber which is kept at a temperature of from 105 to 115 deg. Fahr. for two or three days. Moisture in the atmosphere of this room aids the process and will cause even shriveled fruit to become plump and luscious. The process is inexpensive and perfectly practicable on a commercial scale.

In a recent paper on "Ripening Dates by Incubation," Mr. G. F. Freeman states that the method described of ripening dates artificially by means of heat and moisture is not entirely new. He says: "The Mexican date growers of Lower California cut the bunches of dates after the fruit has passed from the astringent to the sweet stage, but before it becomes soft. The harvested bunches are next put in piles, which, in the open, are covered at night with palm leaves or otherwise to protect them from the dew which would possibly contribute to their decay. Being left in this situation for a varying period of several days, the berries are next picked from the bunches and spread out on mats in the hot sun, the riper being separated from the greener fruit, day by day. At night, during the process, the fruit is protected by covering or piling it, thus measurably maintaining its temperature and keeping it from damage by fog or dew. As the fruit matures it is packed for storage or shipment."

Prof. Freeman holds that the heat of the sun during the day and the sweating effects doubtless brought on by piling or covering at night, offer conditions and produce results more or less similar to the artificial ripening process which he has used. Vinson reports that a certain fruit dealer in Algiers, whose dates are considered superior, is said to have a secret process by which they are treated in order to soften the hard and imperfectly ripened individuals. Other fruit dealers of the same locality are quoted as suspecting that this process consists in steaming or soaking the fruit.

Dr. Vinson recognized the effect of heat and moisture in date ripening as early as 1907. Speaking of Deglet Noor dates, he says: "Under normal conditions, 2 to 25 per cent of invert sugar is formed, but under the conditions necessary for artificial ripening, 45 to 50 deg. Cent. for several days, a much larger proportion is inverted."

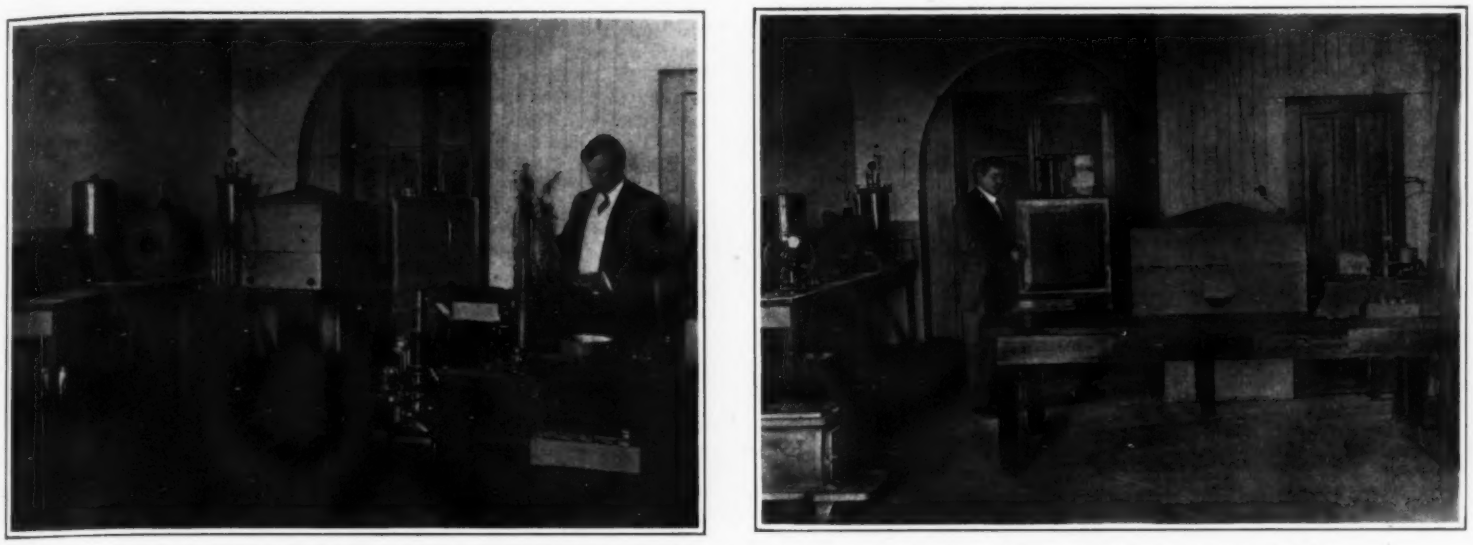
During the crop season of 1910, while Dr. Vinson was absent in France and Africa, Mr. Freeman became interested in the subject and developed the economic method of ripening dates by incubation described.

When the Deglet Noor is fully mature but not yet beginning to ripen the seed is hard, the skin is firm and the external layers of the flesh are opaque. At this time the color is light orange yellow with a strong blush of reddish orange on the sunny side. The first sign of ripening is shown by a slight translucence of the flesh just below the skin. As this increases and progresses toward the center of the date, the fruit begins to soften and wrinkle; and it loses volume with its loss of moisture in ripening. In the early, naturally ripened, invert sugar varieties, the skin is, for the most part, rather thick and brittle, and as the date shrinks it becomes separated from the flesh, dries out and cracks. These cracks offer access to predaceous insects and are ideal receptacles for catching and holding the moisture of occasional showers, thus hastening the souring and decay of the fruit.

The effects of temperature are very marked. The rapidity of ripening increases with a rise in temperature until a point is reached where both the protoplasm of the date and the enzyme which brings about ripening are destroyed. This temperature is stated by Vinson to be about 75 deg. Cent. Mr. Freeman finds that even 65 deg. Cent. is too high to get a good quality of date. Ripening at a temperature of 45 to 48 deg. Cent. finishes the process in three or four days and seems to give the best fruit. Ripened at a lower temperature, a longer time is required and much fruit is liable to sour. At temperatures above 46 deg. Cent. there seems little danger of souring during the ripening process.

The temperature used also affects the color of the finished product. The higher the temperature, the darker the product. Naturally ripened Deglet Noor are of the translucent golden color. In artificial ripening this is changed to a translucent mahogany. This reaches its highest perfection in dates ripened at 45 to 45 deg. Cent. At about 50 deg. Cent. the dates become deep mahogany, lose their translucency and are much less attractive. These higher temperatures also cause the syrupy juice to exude and render the fruit sticky and disagreeable to handle.

Continued exposure to a lower temperature seems to have much the same effect as exposure to a higher degree for a short time. Thus, dates over-ripened (dark colored and opaque) after exposure for five or six days to a temperature of 45 deg. Cent. have much the same appearance as do dates ripened for three days at 52 to 55 deg. Cent. The greener the date, the lower the temperature at which the ripening process may start. When mature dates which show none of the translucent appearance of the beginning of the ripening process are set immediately in an oven having a temperature of 48 to 51 deg. Cent., most of them soon darken and instead of ripening into soft, juicy dates produce a tough, insipid product with a dull gray appearance and leathery texture.



Views in the Laboratory of the University of Arizona in Which the Experiments for Ripening Dates by Incubation Were Carried Out.

Prof. Freeman says: "When these dates are first set in a moist chamber (which, however, must contain no free water) at 38 to 40 deg. Cent. for three or four days, a considerable portion of them will begin to ripen and show the normal translucence and softening. When this occurs, such as are beginning to ripen may be transferred to the higher temperature and promptly finished into a good quality of fruit. I was unable to start more than half of these green dates by this preliminary sub-temperature incubation on account of the molds which seemed inevitably to take possession of the fruit in the ripening trays at the end of about five days. Such dates, therefore, as showed no sign of ripening at the end of four days were considered worthless. It would be interesting here to know just what stage maturity marks the dividing line between the dates that would and would not ripen. Does it depend upon the amount of invertible sugar present or upon the first appearance of the inverting enzyme?"

After the date is well along toward ripeness, high temperatures are not so harmful except that they tend to darken the color and make the date sticky on the outside. After the date is ripe, the temperature may be raised until the date is candied. These candied dates, however, lose some of the characteristic date flavor and are, therefore, disapproved by most people. While high temperatures and over ripening darken the product and candy the dates, they also increase the keeping qualities. The very plump, light colored and juicy date that we have at the first completion of the ripening process is attractive in appearance and delightful to the palate, but many of these, if packed as such, will sour. It is best, therefore, to continue the ripening until the fruit is distinctly shrunken and the juice forms too strong a solution for the growth of yeast and bacteria.

If the ripening is continued until the dates are thus sugar cured they will keep indefinitely, provided they are kept in tight boxes in a dry room. Another and by no means unimportant effect of the temperature upon the dates which are ripened by this method is the destruction of insect eggs. Dates of the Arechti and Deglet Noor varieties, which had naturally ripened on the trees, were carefully selected with respect to quality and freedom from insects and were packed September, 1910, in tightly covered tin boxes lined with oiled paper. The boxes were then securely wrapped in oiled paper with a final wrapping of two layers of ordinary paper.

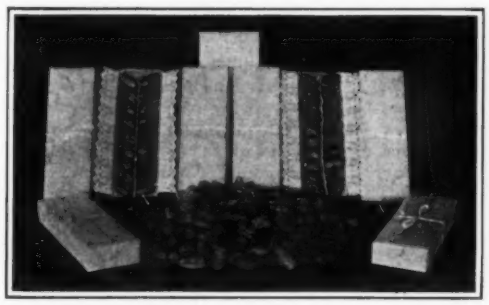
When the boxes were opened about December 15th, practically every date was found to be infested with one or more worms. There is no possible chance that these worms could have entered the boxes subsequently to wrapping, so they must have hatched from eggs laid on the dates before they were packed. Wherever naturally ripened Arizona dates have been packed and put on the market this same complaint has occurred. Worm-eaten dates have, therefore, been a rather serious handicap to the commercial development of our date industry.

With the artificially ripened product, however, this difficulty is at once and completely overcome, for all insects and their eggs seem to succumb to the continuous moist heat of the ripening pans.

The ovens and ripening pans used are of interest. The oven was of zinc and had a double wall to prevent loss of heat. It was large enough to receive eighteen ripening pans holding about five pounds each. Two other ovens were used, carrying about twenty-five pounds each. The total capacity of the plant used was therefore about one hundred and fifty pounds. Flat graniteware pudding pans of five to eight pounds capacity were found most satisfactory for use as ripening pans. Tightly fitting tin covers were used on these, but graniteware covers do not corrode and would be better if they could be secured.

The influence of moisture is most important. The dates, after sorting, are washed to remove the dust and dirt which inevitably collects upon them. They are then drained thoroughly before being put into ripening pans. From poorly drained dates water is liable to collect in the bottom of the pans and cause sourness or stickiness of the finished product. Unless the dates are already shrunken, five or six hours' contact with free water will cause the skin to break on many of the fruits.

It is held that in a commercial plant it would probably be best to dry the washed dates for a few hours



Deglet Noor Dates, Grown, Ripened and Packed by the Arizona Agricultural Experiment Station.

on wire drying racks in an oven. The temperature should be about 40 deg. Cent., with free air circulation. When there is no moisture left on the exterior of the dates they are ready for the ripening pans.

It is advisable to place cloths or low wire screen racks in the bottoms of the ripening pans in order to absorb or raise the dates above any syrup that may drip from the fruits.

The soft or translucent dates lose about ten per cent of weight in ripening. This loss is water, and the bulk of the date decreases coincidently with a decided shriveling and wrinkling of the skin. The ripening pans are at first left open (usually twenty-four to thirty-six hours) until the skin begins to wrinkle perceptibly. The covers should then be fitted on tightly so that the remainder of the process of ripening takes place in a saturated atmosphere. When the covers are put on too soon souring is more likely to occur. An additional and more serious danger is that the dates ripen into exceedingly soft and juicy fruit. If packed in this condition such fruit will not keep. On the other hand, if the dates are dried down to packing weight, the shrinking flesh pulls away from the skin, leaving the latter to dry into an undesirable loose, papery shell.

As the date begins to shrivel in the early part of the ripening process, the skin will continue to cling to the flesh. This keeps the skin soft and tender and results in a finished product, which is a shrunken but still translucent and clean (not sticky) fruit. It is an important consideration in the production of a fancy confection date that it may be eaten from the hand without soiling the fingers.

The chemical study of this process is of special interest. The artificially ripened Deglet Noor date is decidedly a different product from that which naturally ripens on the tree. The former is an invert sugar date, while the latter, as has long been recognized, contains principally cane sugar. This may be seen in the following table of analyses:

TABLE I.—COMPOSITION OF DEGLET NOOR DATES

| Lab. No. | Kind of dates. | Moisture. | Calculated to water-free material. | | |
|---|---|---|---|---|---|
| | | | Cane sugar. | Fructose and glucose. | Total sugars. |
| | | Per cent. | Per cent. | Per cent. | Per cent. |
| 4585 | Naturally ripened.... | 17.23 | 61.30 | 26.72 | 88.02 |
| 4584 | Drymummies (class 3) | 21.21 | 60.73 | 22.75 | 83.48 |
| 4576 | Artificially ripened (class 2)..... | 24.95 | 18.51 | 61.01 | 79.52 |
| 4581 | Artificially ripened (class 3)..... | 28.75 | 13.65 | 72.22 | 85.86 |

The principal factors governing the amount of inversion are heat and moisture. The influence of each separately and in combination is shown in the following table from Prof. Freeman's paper on "Ripening Dates by Incubation."

TABLE II.—EFFECTS OF THE VARIATION OF HEAT AND MOISTURE ON INVERSION.

| Lot and kind of dates. | Treatment. | Duration of Incubation. | Temp. of Incubation. | Moisture content when ripe. | Calculated to water-free material. | |
|---|---|---|---|---|---|---|
| | | | | | Cane Sugar. | Total Sugars. |
| | | Hours. | Deg. C. | Per Cent. | Per Cent | Per Cent. |
| 1 Soft mummies.. | Soaked in water 7 hours at 49 deg. C. | 117 | 49 | 29.15 | 12.69 | 84.37 |
| 2 Soft mummies.. | Left dry..... 7 | 117 | 49 | 23.16 | 26.98 | 87.44 |
| 3 Soft mummies.. | Soaked in water 7 hours at 20 deg. C. | 117 | 20 | 33.44 | 37.80 | 85.82 |
| 4 Soft mummies.. | Left dry (check).... | 117 | 20 | 23.28 | 46.80 | 83.97 |
| 5 Hard mummies. | Soaked in water 7 hours at 49 deg. C. | 117 | 49 | 28.75 | 13.64 | 85.86 |
| 6 Hard mummies. | Left dry..... | 117 | 49 | 19.63 | 44.89 | 83.54 |
| 7 Hard mummies. | Soaked in water 7 hours at 20 deg. C. | 117 | 20 | 25.91 | 47.52 | 82.59 |
| 8 Hard mummies. | Left dry (check).... | 117 | 20 | 21.21 | 60.73 | 83.48 |

The dates used in these experiments had been lying in the laboratory at room temperature for about a month. However, the inverting process had probably been going on slowly in them for the two months after they first began to ripen. There were two classes of dates.

Those in which partial ripening had occurred and which were therefore somewhat soft, but not sufficiently ripe to be marketable, were termed "soft mummies," and those which had dried down to a hard and brittle condition were termed "hard mummies." Under natural conditions, slow inversion had occurred in both, but it seems to have been more active in those which were most advanced in ripeness. By deducting the cane sugar found from the total sugars present, it is seen that in wholly untreated samples 4 and 8, representing these two classes, there was 37.17 per cent of invert sugar in the soft mummies and 22.75 per cent in the hard mummies.

It is interesting, moreover, to note that the per cent of moisture at the time the analysis was made was slightly higher in the soft than in the hard mummies. The slow inversion in these two samples was most probably due to the fact that though there was sufficient heat and moisture for feeble activity of the inverting agents present, neither was at or near the optimum degree of intensity. When the temperature alone was raised there was an increased inversion amounting to 19.82 per cent in the one case and 15.84 per cent in the other. As to the influence of temperature alone, Table II gives only two instances, 20 deg. Cent. and 49 deg. Cent. In another experiment the result of

which is given in Table III, dates were first soaked in water until swollen and then ripened at intervals of ten degrees from 40 deg. Cent. to 90 deg. Cent.

TABLE III.—EFFECT OF DIFFERENT TEMPERATURES AND MOISTURE ON THE INVERSION OF CANE SUGAR.

| Lot No. | Temperature of soaking. | Time soaked in water. | Temperature of incubation. | Time incubated. | Moisture. | Calculated to water-free material. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Acidity as $H_2SO_4$. | Cane sugar. | Fructose and glucose |
| | Deg. Cent. | Hours. | Deg. Cent. | Hours. | Per cent. | Per cent. | Per cent. | Per cent. |
| 21 | Check | ..... | ..... | ..... | 19.90 | 0.309 | 54.92 | 29.99 |
| 27 | 40 | 12¾ | 40 | 95¾ | 28.67 | 0.317 | 26.55 | 57.06 |
| 28 | 50 | 13 | 50 | 70 | 31.41 | 0.354 | 9.94 | 75.01 |
| 29 | 60 | 8¾ | 60 | 25¼ | 30.86 | 0.334 | 24.88 | 59.00 |
| 30 | 70 | 6¾ | 70 | 24½ | 34.52 | 0.403 | 23.73 | 58.43 |
| 31 | 80 | 4¾ | 80 | 13½ | 29.08 | 0.382 | 38.67 | 45.36 |
| 32 | 90 | 2¾ | 90 | 10 | 22.65 | 0.428 | 42.23 | 41.55 |

It has been found that attempts to conserve cane sugar by ripening the dates at or below 40 deg. Cent. result in prolonging the exposure necessary for the completion of the process and strongly increases the liability to sour. On the other hand, at temperatures above 55 deg. Cent. (55 to 65) although not more than half of the time necessary for ripening at 50 deg. Cent. is required, great care must be exercised in order to prevent the production of dark colored, sticky dates. Although there is more cane sugar present, dates ripened at these high temperatures do not have so pleasing a flavor as do those ripened with less heat.

Prof. Freeman holds that the inverting agents of the Deglet Noor date do not reach their greatest activity under the conditions surrounding the trees as grown up to the present time in Arizona. Such of these dates as naturally ripen in this climate, therefore, having very little of their sugar inverted. Their inverting agents require for their greatest activity, temperatures distinctly higher than occur naturally during the ripening season in Arizona.

He claims that the ripening of a cane sugar date is a process separate and distinct from the inversion of the cane sugar present, and that conditions favorable for the rapid ripening of the Deglet Noor date may be produced artificially in an oven by regulating the degree of moisture and temperature. In this ripening process the tissues of the date are softened and the tannin is precipitated, thus relieving the date of its astringency.

It is further claimed that the same conditions of moisture and temperature used by Prof. Freeman in ripening Deglet Noor dates were also favorable for great activity of the inverting agents present in these dates. The artificially ripened product therefore differs from that naturally ripened in having nearly all of its sugar in the inverted form.

It is rather interesting to note how the application of the most modern scientific methods steps in at every point of industry, and seems to be calculated in this particular instance to establish in our own country the cultivation of a product, which for centuries past has come from the more tropical regions of the old world. The case might be regarded as a peculiar type of adaptation; since the palm tree cannot adapt itself to the climates in which we live to the extent of ripening its fruit for our use, the ingenuity of modern man steps in and substitutes, as it were, an artificial climate during the last stages of the ripening process. We might say, on the pattern of an old Mohammedan proverb: "If the palm will not adapt itself to the climate, then we must adapt the climate to the palm."

The University of Arizona is to be congratulated on the work done by its agricultural experimental station in developing this new process of ripening dates by incubation.

# High Vacua: Their Production and Properties*

## The Radiometer as a Delicate Pressure Gage

By W. R. Whitney

THE purpose of this article is to publish a few observations made in the research laboratory on some phenomena in vacua, as they may possibly be of interest to others who are working in the field of evacuated apparatus.

The subject has a double interest because at first glance it seems difficult to see how there can be much ground for study, or material and phenomena for useful investigation in such an apparently confined *volume* of nothingness as the vacuum of an incandescent lamp. The many actual developments from this lack of material are interesting, and there is the added interest, due to the fact that there are to be found in these lamps examples of many of the phenomena of gaseous ions which are receiving so much study in our day.

It has long been known that the life of an incandescent lamp is greatly influenced by the quality of its vacuum. In general, one may say that the better the vacuum, at least up to a certain point and until recently, the longer the life of the lamp. In the early days of lamp making, many schemes were devised to improve the vacua. This was then all the more necessary, as the mechanical methods of lamp-exhausting were very much inferior to present ones. The harmful effects of oxygen and water vapor, both of which reacted upon the filaments, were well known and many ways were devised for removing them.

What seems to be an especially interesting method of supplementing the vacuum pumps was the method of Malignani. This process, in its most perfect form, consisted in distilling into the bulb a small amount of some such substance as arsenic, iodine, or phosphorus. At the instant when one of these vapors was introduced, he passed a high current through the filament, the lamp being closed from the pump. This has long been the common commercial process for lamps which are to operate on voltages above 50, and many millions of lamps have been exhausted by its aid.

In the case of incandescent lamps where the voltage is above 50 for a fair brilliancy of filament, a blue discharge passes through the bulb and this blue quickly disappears when such vapors are introduced. The blue discharge seemed to be necessary for any considerable improvement of the vacuum, due to such vapors as phosphorus, and this led to the assumption that the gases still left in the lamp by the pump, were removed quickly during the blue glow and probably by the vapors which were at the same time being deposited on the glass. Although the facts were pretty well known, we performed experiments to study the phenomena. It was found that when the vacuum was measured by a McLeod gage, the sudden marked improvement of vacuum was easily proven. For example, in experiments carried on by Mr. Willey, of the laboratory, when the pump had produced a vacuum of 0.030 millimeter mercury and the cock leading to it was closed, a trace of phosphorus was distilled into the bulb while the filament was very hot and a blue glow had appeared; then about as quickly as the gage could be read the pressure had fallen to 0.002 or 0.001 millimeter.

That this improvement of vacuum is quite commonly produced when vapors of any kind are caused to condense in the space is not new. It even takes place markedly when the filament is first heated to very high temperature without added vapor, and a *blue glow* also passes through the lamp at the time. In improving the vacuum this latter way, however, it is known that the filament is injured and apparently a part of its material has been vaporized. This process soon causes blackening of the bulb by carbon.

This vaporization of phosphorus into the lamp at the moment when the pump has done its work, has long been the commercial method of finishing the exhaustion of incandescent lamps. The fact that even the carbon alone tended to the same end, though at the expense of the filament, being recognized, it became of interest to get a clearer view of this phenomenon.

In other words, if an incandescent lamp was burned while connected to a McLeod gage and the vacuum became poorer, the changes of vacuum might be measured by the gage from time to time. If, on the other hand, the vacuum improved so that the pressure tended to become less than the vapor pressure of mercury at the temperature of the gage, then the gage would not only not measure it, but the mercury vapor might even have affected the life of the lamp. When experiments were made to determine the effect of the vapor of mercury at the low pressures corresponding to a micron, which is the vapor pressure of mercury at 15 deg. Cent., very peculiar results were obtained and the lamps showed very early blackening. It looked as though even the presence of this constant mercury pressure was fatal to the lamp. Therefore the discovery of a more practical vacuum gage was desirable.

Without committing ourselves to a theory, we can describe one or two interesting experiments with mercury vapor. It was first discovered that an incandescent lamp grew black very quickly when attached to a mercury column which served as a gage to indicate evolution of gas. No such combination could be made to last over a few hours. The lamp blackened just as though it were in an imperfect vacuum. It is hard to see how the mercury can have any chemical effect upon the filament as oxygen or water have, and the effect is common to carbon and tungsten lamps. Many lamps were then made which were exhausted as perfect lamps are exhausted, except that a small quantity of mercury was left in the bulb. It was assumed that this would not interfere with the removal of air and moisture and might even assist by the washing effect of the mercury vapor, mechanically removing air. Lamps were also made in which a large quantity of mercury was placed, the lamp put into an oven above the boiling-point of mercury and the air washed out by the distilling mercury, no pump being used. When the mercury was nearly all removed the bulb was sealed off. This method, if no visible mercury is left in the bulb, is capable of giving good lamps, but where a visible drop of mercury was present the lamp would show a persistent blue glow and rapidly blacken, even below its normal voltage. In some cases it would arc between the leads, exactly as in the case of poorly exhausted lamps.

Lamps were also made to which were attached tubes which carried small globules of mercury. When these side tubes were short and straight, such as one or two inches, and the lamp was exhausted as well as possible on the pump, the blackening of the bulb started at once when the entire glass was at ordinary temperature. If now, the side tube with its mercury was submerged in different cooling mixtures, the length of time for a given blackening was increased. For example, at room temperature the lamp would be blackened so as to correspond to 80 per cent of its original candle-power in a few minutes. When the side tube containing the mercury was at 0 deg. Cent. this time became two or three hours, and when cooled in a freezing mixture at 20 deg. Cent. the life to 80 per cent was over 75 hours. Such differences were also noted when the pressure of mercury vapor was controlled by using cadmium amalgams, the amalgams higher in mercury corresponding to the shorter lamp life.

It was interesting to note also that by lengthening the side tube containing the mercury, the rate was decreased at which this filament material was deposited in the bulb.

In a set of experiments at ordinary temperatures the length of the side tube was increased and it was wound in a spiral. This reduced the rate at which the mercury could reach the bulb proper. In this case, instead of there being a continuous faint blue glow, as there is when the mercury is in a short side tube, the blue glow appeared and disappeared continuously and regularly. It looked as though there was a certain pressure of the vapor necessary before the blue discharge could occur and that when this was reached, the sudden discharge produced the blue and cleared the vacuum to a much lower pressure. Then mercury vapor distilled anew from the long side tube until again the necessary pressure was reached, when the process of clean-up repeated itself.

If the lamp bulb was kept very hot, the blackening was reduced and even done away with altogether, although the deposition of the mercury vapor upon the glass by the discharge signalized by the blue glow could not take place. If, however, water vapor was present, even in very small amount, the blackening would take place very rapidly, even in the absence of mercury. In other words, most ordinarily, exhausted lamps will blacken relatively quickly if allowed to burn in a heated oven. In general, the hotter the oven the more rapid the blackening, but this process is largely, if not entirely, due to imperfect exhaustion. All glass contains water which can be removed but slowly, even at relatively high temperatures. It has even been found that indefinite heating of a lamp connected to the vacuum pump is not capable of removal of all of this water. If exhaustion is carried on for a very long time at room temperature, then merely raising the temperature will cause liberation of more gas and after heating and exhausting to an equilibrium condition at say 200 deg. Cent. more water will be produced on heating to 300 deg. Cent. and still more at 400 degrees. For this reason it is customary to exhaust at as high a temperature as possible. At 400 deg. Cent. the ordinary glass has reached its limit, owing to the proximity of the softening point. For this reason we have had to exhaust the oven in which the lamps were

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being exhausted, in order to study the water evolution at higher temperatures.

For a long time it was impossible to follow the change of vacuum in a lamp, because the pressure could very evidently not be reduced below the vapor pressure of the mercury of the McLeod gage attached to the lamp. It has long been known also, that the current passed through the space of the bulb to a considerable extent, and that this varied with the degree of vacuum, etc. A very complete discussion and description of experiments on this so-called Edison effect are given by Prof. Fleming, in Vol. 42 of the *Philosophical Magazine*. In general, the conclusions are that in the vacuum of an incandescent lamp a current can flow across the space from the negative end of the filament to any conductor in the bulb, if this be so located that particles passing in straight line from the negative leg may come into contact with this conductor. This latter was usually a small platinum plate, and to it, as anode, a continuous current flowed from the negative half, or end of the filament, except when it was intermittently shielded from direct emanations. The current often of several milliamperes was measured by a galvanometer connected between the metal plate and the positive terminal of the lamp. It is known that the materials of the filaments distill in straight lines and cast well defined shadows, because the mean free path at this pressure is greater than the diameter of the bulb, and it was natural to assume that this vaporizing carbon carried electric charges of negative sign. This assumption might seem to acquire the more rapid wasting away of the negative half of the filament than the positive, but no data are present to prove this. When condenser charges were superposed on this apparatus it was found that with the negative end connected with the negative side of the condenser, the condenser was at once discharged. When connected oppositely, it was not discharged. Current could pass as negative from the hot conductor or filament, but not from the cold plate, nor could positive current pass from either the hot or cold terminal.

In connection with this work of Fleming's, we have studied the effect of the condition of vacuum on the current, and also found that the presence of gas is necessary for this negative discharge. In general, the higher the pressure of the gas when this does not exceed a few thousandths of a millimeter mercury, the greater is the current. This makes it seem improbable that the current is solely dependent on the passage of carbon or tungsten from the filament to the positive electrode, though it leaves the possibility open that the current may be carried by gaseous ions produced by negatively charged material coming from the negatively charged filament.

By using alternating current and a metal electrode in a carbon lamp, Fleming obtained direct current on the circuit connecting the metal plate to either terminal of the lamp and the current was in the direction expected, the plate being negative to the terminal.

This outfit is thus obviously a rectifier, and it has been so used by Fleming for low currents.

The effect of a magnetic field on this gaseous conduction, just as in the case of metallic bismuth, is to increase the resistance.

It was finally found that the Crookes radiometer was a very sensitive gage for the changes of pressure in lamps, and by its use the changes could be followed in a qualitative manner, even throughout the life of the lamp, by having the radiometer sealed directly to the lamp. Dewar has shown the sensitiveness of this apparatus in the *Proc. Roy. Soc.*, 1907, 531.

The radiometer consists of a glass bulb containing a perpendicular needle with a glass cap on which are four aluminium arms with a mica vane at the end of each. One face of each mica vane is coated with lamp-black. When the radiometer is evacuated to a high degree, the effect of radiant energy or light is to cause rotation, which is believed to be due to the fact that the molecules of gas take up energy from the blackened surface of the vanes more than from the plane surfaces, the black absorbing more of the incident energy and thus locally heating the gas molecules. These in the rarefied atmosphere largely give off this energy to the walls of the apparatus by direct impact, rather than to other molecules in the neighborhood of the vane. This results in a motion of the vane opposite to the motion of the gas molecules, because the unblackened face of the vane receives impact mostly from these cooler molecules.

The vacuum of the lamp as sealed from the pump approximates a few microns and is poor enough so that the radiometer rotates rapidly when exposed to light. By using a fairly constant light intensity and noting its effect upon a radiometer attached to a lamp which was lighted for intervals, it was seen that the radiometer gradually rotated slower and slower, and finally after a period of normal lamp brilliancy from 12 to 36 hours on tungsten lamps, it would stop rotating altogether. At this point it was found that a more sensitive measure of still higher vacua could be gained by starting in the dark by mechanical motion a rotation of the vanes of a definite speed, and noting the rate of speed decay on standing. This was done by proper spinning of the whole apparatus in the hand and then getting the rate of decrease in this rotation of the vanes by counting definite revolutions after definite time intervals. Here the friction of the residual gases was merely overcoming the momentum imparted mechanically to the vanes at start. In this way even by comparing the minutes required for the radiometer to come to a stop, quite interesting information was obtained.

This method was not developed into a quantitative one, though it might have been. The radiometer method shows us, however, some interesting facts which are worth describing. Using the common type of radiometer often seen in jewelers' windows and sealing this directly to a lamp made from 110 volt circuit, the radiometer would rotate when in daylight. This showed the presence of some gas in the lamp and the McLeod gage used at the time of sealing the lamp from the pump showed approximately 2 microns. If, now, the radiometer and the lamp were removed to a dark room and a rotating motion imparted to the vanes, they would proceed to rotate for about a minute, this time depending somewhat on the particular radiometer used, as well as on the condition of the vauum.

Since at the moment when the filament was at bright heat and the vacuum very poor (so poor, in fact, that if the pressure were maintained constant the lamp would blacken in a few minutes), the vacuum greatly improved, owing to some action occurring together with spattering of the filament, it seemed important to know more about the phenomena. We assume that the gas at first present goes to the walls of the lamp and is held there, possibly absorbed by the small quantity of deposited filament material. It is always possible to drive the greater part of it back into the vacuum space by warming the glass. It seemed perfectly possible that the process might be a cyclic one; that is, the gas carrying to the walls of the bulb some of the filament material and not of necessity remaining there, but possibly returning for a fresh supply. This continued process might account for the limited life of an incandescent lamp. It did not seem necessary to assume that there was any measurable rate of simple distillation from a carbon filament at the temperature of operation, though such a phenomenon could account for limited life of filament. It even seemed possible that the cyclic process, instead of being physical, might well be expressed as a chemical one, such as we know could exist, and might continue between the oxides of carbon and carbon itself. At the high temperature of the filament carbon monoxide would be expected but this, at a lower temperature, would form $CO_2$ and free carbon, the latter being deposited upon the glass. The free $CO_2$ coming into contact with the hot carbon filament would again form carbon monoxide, and thus the process be repeated continuously until the filament was burned through or the lamp became too black to be of use. It was therefore desirable to get a closer insight into the phenomena in the lamp at a few microns pressure.

Similar considerations can apply equally well to the case of tungsten filament lamps. In the case of osmium lamps this reasoning extended, explains the fact that the presence of a little oxygen in the lamp was necessary to prevent blackening of the bulb by the deposited metal. A little oxygen in a carbon lamp might similarly remove deposited carbon from the glass and deposit it upon the filament, if the temperature at the two points were suitable, but with this element it seems impracticable because the oxide formed is not easily reduced below the CO state, thus differing from osmium.

While the lamp to which a radiometer was attached was not lighted, practically no change in vacuum could be detected by the radiometer. Therefore there is no leak of air from without. If, however, the lamp was lighted, the reverse was true. On allowing the lamp to be lighted for a few seconds only, and then cooling and testing in the dark room as before, the duration of rotation would usually be shorter, thus indicating a liberation of gas into the bulb space by this short time of burning. If, however, the lamp were allowed to burn at a normal brilliancy for a longer time and the same vacuum test was made from time to time on the unlighted lamp in the dark room, it was found that the duration of the impressed rotation rapidly increased. In many cases a rotation lasting 15 minutes would be produced by allowing the lamp to burn 24 hours. This phenomena of automatic vacuum improvement received the name of the "clean-up." While the clean-up, as measured in this rough way, did not seem to take place in all lamps to the same degree, it was always present under ordinary conditions.

Other types of vacuum lamps improved their vacua on running. In fact, no lamp, unless we except the mercury arc, fails to do so. The well-known Moore tubular system of lighting, which is a development of the Crookes tube, consumes the gas, and for that reason an automatic valve was invented which supplies air to the tube when the vacuum improves to a certain point. It is also an old story, in the case of the cathode and X-ray tubes. X-ray tubes are usually made with a salt, such as potassium chlorate or potassium hydrate, mica, asbestos, etc., in an attached side tube. This may be heated when the tube in use attains too high degree of evacuation, and in this way gas is liberated into the bulb. This is in turn removed from the vacuous space by the operation of the tube. A natural question is raised at once: what becomes of these disappearing gases? In some cases they are probably forced or shot into the glass itself, for some of these old glasses bubble on being heated to the softening point. Possibly the greater part of the gas is absorbed by the exceedingly finely divided metal,which slowly deposits on the glass as it vaporizes from the electrode.

If an incandescent lamp, the vacuum of which had been thus cleaned up, was allowed to stand unlighted at ordinary temperature, the vacuum, as indicated by the test, would gradually grow poorer, though it would seldom fall to the starting value. If the bulb were heated in an oven at 100 deg. Cent. for a few moments, it would also show a poor vacuum again on cooling. If such a spoiled vacuum lamp was again lighted, it would at once commence to recover its previous high vacuum. There was no indication of a fatigue evinced in lamps thus treated.

This explains the fact noticed in the case of most factory made incandescent lamps, that their life at constant voltage varies with the external temperature. It is as though the gas, which is at first present in the space of the sealed bulb and is then thrown upon the walls by the clean-up, is also continually driven off from the walls at a rate dependent upon the wall temperature, and the deposition is bound up with some loss of filament material.

The experiments with the radiometers naturally led to attempts to develop more nearly quantitative apparatus which would still measure the low pressures of gas under consideration in incandescent lamps. Among the promising methods was that described by Pirani (*Ber. Deut. Phys. Ges.* 1906, 686). This was further developed by Dr. Hale of this laboratory, as described in the *Transactions* of the American Electrochemical Society, 1911.

This gage depends on the principle that energy loss from a heated wire in the vacuum to be measured depends on the pressure of the gas present. When the temperature of this wire is low (100 deg. Cent., for example), the losses by radiation are relatively small, so that the rate of loss at a constant temperature of wire would serve to determine the gas pressure. Conversely the temperature of this wire, if supplied with constant energy, from the battery, for example, would be higher the lower the gas pressure. This latter scheme was adopted by Dr. Hale, and the gage consisted in a glass bulb sealed directly to the lamp to be measured and containing about two feet of fine platinum wire. This was heated by a current of constant watts and the temperature of the wire was given by knowing its temperature resistance coefficient and measuring the actual resistance for the case in test.

The measurement involved extrapolation toward perfect vacua from comparative measurements made with the new gage and the McLeod gage at pressures high enough so that the latter is reliable. Hale concluded that he could measure differences of pressure of one hundred thousandth of a millimeter of mercury, or a hundredth part the vapor pressure of mercury at zero centigrade. Here was a gage which, unlike the McLeod, exerted no appreciable vapor pressure of its own and therefore could serve to indicate the existing pressure at any period of the life of the lamp. It could disclose the fact if gases were produced within the burning lamp, if the seals or glass leaked at all, and how the clean-up actually changed the vacuum as indicated by the radiometer experiments. In using this gage new and interesting phenomena were disclosed, which must be further studied. In certain cases vacua a little more than perfect are indicated by this gage, and this suggests possible dissociation of the very attenuated gas. Barring this fact, it seems as though the clean-up effect proceeds to as nearly perfect vacuum as we can measure even qualitatively.

**Transfer Paper.**—Distribute 250 parts of pure starch in a small quantity of cold water and add 1,500 parts of boiling water, slowly and constantly stirring. To this starch-water add, stirring slowly, a mixture of 10 parts of neutral chrome yellow and 4 parts of gum arabic, dissolved together in water. To the whole 500 parts of glycerine are added, and to prevent the formation of a crust, the whole is kept in motion until completely cooled. To free it from undissolved or other solid particles, it must be carefully pressed through fine bolting cloth and is then ready for application to the paper. This is effected by means of soft brushes, particular care being taken to insure even distribution. The finished sheets are dried by suspension in the air. The paper remains moist and can, therefore, be kept in an unrolled condition. This makes the moistening of the stone or the plate unnecessary and the transfer retains the same size as the negative.

## Science Notes

**Phosphorescence.**—It is well known to everybody that phosphorus exposed to the air undergoes oxidation, the action being attended with the emission of light, though the temperature is far below that of ordinary incandescence. It is less well known that sulphur heated to 250 deg. Cent. displays a similar effect, as does also arsenic at a somewhat higher temperature. Dark red heat is not reached until the temperature is about 500 deg. Cent.

**Translucent Marble.**—According to a note in *Prometheus* specially treated marble slabs have been used with very good artistic effect for purposes of diffuse illumination. The slabs are polished on both sides and are then soaked in oil, paraffin or shellac. The impregnating liquid may be applied hot or cold and with or without pressure, according to the effect aimed at. It is stated that the loss of light on transmission through these plates is only 20 per cent.

**Chrome-nickel Bronze.**—Chrome-nickel bronze is now being manufactured by a Philadelphia company, the product being known as "Chromax Bronze." The proportions of metal in the alloy are said to be as follows: Copper, 66.66 per cent; zinc, 12.13 per cent; nickel, 15.15 per cent; chromium, 3.03 per cent; and aluminium, 3.03 per cent. The tensile strength of the alloy is said to be 79,000 pounds per square inch; the color is white, and it takes a fine, silvery polish; the fracture is fine and dense, particularly after being remelted; and the alloy, owing to its high melting point, has a denser structure and greater compressive strength than manganese bronze. It can be rolled into sheets and wire.—*The Journal of Industrial and Engineering Chemistry.*

**The Temperature of Volcanic Lavas.**—Measurements have recently been made, by means of a Féry optical pyrometer, of the temperature of the lavas from the crater of Etna. An Italian scientist, G. Platania, records his observations in the *R. Accadem. dei Lincei.* At a point situated some 250 feet from a discharging crater he sighted a lava stream flowing at the rate of 3 feet per second at its central portion. The temperatures observed at two different points were 560 and 770 deg. Cent.; subsequently the stream was approached to within some 13 feet, and a new set of measurements gave 795, 814, and 825 deg. Cent. For a moment the rolling over of a large block exposed a bright patch which showed a temperature of 940 deg. Cent. It may be remarked that in 1910 M. Odonne made somewhat similar measurements and found temperatures up to 1,200 deg. Cent.

**The Size of Animals.**—In a recent number of *Prometheus* Karl Sayo discusses the conditions which may have influenced the size of animals in past geological ages and in our time. He points out that in the fossil fauna we find species vastly larger in size than their congeners now living. A number of possible causes for this are discussed, only to be laid aside as highly improbable. Thus the author points out that even now aquatic animals reach a very considerable size, as for instance in the case of the whale, and the author suggests that this may be in part due to the buoyancy of the water, which as it were counteracts gravity, and renders large animals more mobile than they could be on *terra firma.* It might therefore be supposed that in past geological ages the weight of bodies on the earth was less than to-day, and thus enabled large animals to make a successful fight for existence under circumstances in which they could not now survive. As a possible cause of increased weight in our present epoch it is pointed out that the earth formerly revolved faster, and that hence centrifugal action was greater. But that seems a very far-fetched and highly improbable explanation.

**Electric Accumulator Charged by Light.**—The direct utilization of the sun's radiant energy may be said to be one of the great industrial problems which the science of to-morrow must solve. Suggestive in this direction is the work of Charles Winter, recorded in the *Revue Electrique*, on a "light accumulator." This consists of two platinum electrodes dipping in ferric chloride, and one of them in contact with mercurous chloride. On closing circuit, the current passing through the ferric chloride decomposes this into iron and chlorine. The iron reduces the ferric to ferrous chloride, while the chlorine reacts with the mercurous chloride, converting it into soluble mercuric chloride. The electromotive force depends on various factors, including the temperature. It may reach 138 millivolts. The current on short circuit is about one milliampere.

To charge the cell, it is simply exposed to the action of ultra-violet light from a mercury vapor lamp. The reaction noted above then simply proceeds in the inverse order. Sunlight produces the same effect in a very much smaller degree. While the amounts of energy here involved are altogether too small to be of practical value, these experiments are of the highest interest as pointing the way toward one possible solution of the problem of the utilization of the sun's rays.

## Trade Notes and Formulæ

**Bell Metal for Clocks.**—Alloy *a*: 75 parts copper, 25 parts tin. *b*: 73 parts copper, 27 parts tin.

**Rainbow-Colored Coating for Metal.**—42.5 parts hyposulphite of soda, dissolved in 450 parts of water; add to this a solution of 45.5 parts sugar of lead in 250 parts of water. Place the object in this and heat gradually to 189 to 197 deg. Fahr.

**The Production of Wood Stains.**—Wood stains are made on a large scale in England, and are exported thence to other countries. Whereas, on the Continent, almost exclusively coloring substances are employed that, penetrating into the wood, impart the color to it, in England wood stains are used that contain at the same time a binder, which, on drying in water, becomes insoluble, insuring a more permanent connection with the wood. As binder, shellac-borax solution is employed, obtained by boiling; the coloring substances are then added to the hot solution and heated with it until they are dissolved. The liquid is allowed to cool, filtered through linen, and the finished stains are filled into bottles in which, tightly sealed, they remain for years unchanged.

Ebony stain: 27 parts water, 27 parts ground blood shellac, 1.55 parts ground borax, 0.45 part water-soluble coal tar dye.

Walnut stain: 22.5 parts water, 2.25 parts ground garnet shellac, 1.13 parts ground borax, 0.405 part water-soluble tar color (nut brown).

Oak stain: 27 parts water, 2.7 parts ground orange shellac, 1.35 parts ground borax, 0.47 part water-soluble tar color (oak brown).

Pine wood stain: 36.5 parts water, 3.65 parts ground bleached shellac, 1.8 parts ground borax, 0.372 part water-soluble tar color (pine wood brown).

Satinwood stain: 27.5 parts water, 2.75 parts ground bleached shellac, 1.38 parts ground borax, 0.465 part water-soluble tar color (satin yellow).

Mahogany stain: 27.5 parts water, 2.75 parts ground orange shellac, 1.38 parts ground borax, 0.56 part water-soluble tar color (mahogany red).

Green wood stain: 27.5 parts water, 2.75 parts ground garnet shellac, 1.38 parts ground borax, 0.37 part water-soluble green tar color.

Rosewood stain: 22.5 parts water, 2.35 parts ground garnet shellac, 1.13 parts ground borax, 0.67 part ground water-soluble tar color.

Poplar wood stain: 22.5 parts water, 2.25 parts ground bleached shellac, 1.13 parts ground borax, 0.418 part water-soluble tar color.

Blue wood stain: 27.5 parts water, 0.9 part strong vinegar, 9.6 parts ground orange shellac, 1.8 parts ground borax, 0.39 part water-soluble blue tar color.

In the last described stain the borax-shellac solution is prepared, then the solution of tar color in vinegar, the latter powdered into the former and thorough mixture effected.

English coal-tar color factories furnish the water-soluble colors required for the stains.—*Oesterr. Farben und Lack Ztg.*

**Polishing Eating Utensils.**—For polishing knives and forks, hammerscale and sand are still extensively used, but these agents are too severe on the blades and leave them scratched and full of notches. Fat and other dirt being the more difficult to remove from knives the longer it is allowed to remain on them, they should be cleansed immediately after use at the table by dipping them in warm water and wiping them with a woolen rag or blotting paper; only the water used must not be too hot, otherwise the blades are softened and the coating of the handles, if this is immersed too, is rendered unsightly. The silver and German silver knife handles are filled with a substance composed mainly of rosin. If the knife is placed in water that is too hot this mass expands and either forces the blade out of the handle or extends the latter, so that if the metal is not very strong it will burst. By washing in hot water we certainly remove fat and other coarse impurities. Nevertheless, the knives, etc., always require polishing to make them bright before using again, because moisture causes them to tarnish even if after washing in water they are thoroughly dried. The following methods may be recommended: 1. The knife is laid, as far as the handle, on a sheet of paper and firmly held in the left hand, while with the right it is rubbed with a piece of cork and tripoli, or what is better, with finely sifted lime. The blade having been thus treated on both sides is wiped off with a woolen rag. When the cork has once become impregnated with the dry lime or tripoli it lasts for a long time. Even more conveniently is this accomplished by firmly attaching a strip of thin cork to a small board and applying the polishing powder to it. In this case the knife or fork is passed backward and forward over it. This arrangement especially facilitates the cleaning of forks. 2. A board is covered with leather and to this melted mutton fat is applied by means of a piece of flannel. Then rub two soft fire bricks against one another so that the resultant dust falls on the leather and rub this dust into the leather so that no more fat comes through when a knife is passed over it. This we know because the latter retains its polish. Then take a knife in each hand, holding them with the backs turned to one another, and move them back and forth without exercising too much pressure. By this means, with a little practice and without risk of breakage, one can clean two knives at once. 3. For the most convenient cleaning of forks fill a small keg with fire brick dust or sand mixed with a little hay or moss and keep this mixture always moist. If the tines of the forks are thrust into this mixture a few times all spots on them will disappear. In addition we must have a small piece of wood shaped like a knife and covered with leather to polish in between the tines after we have carefully brushed off the dust on withdrawing them from the keg. 4. The Englishman, Winterton, gave the following method of polishing rusty knives. The knife to be polished is well rubbed with wax and exposed to fire heat until red hot. Then place it for ten minutes in a mixture of equal parts of vinegar and water which has been saturated with common salt, or better with saltpeter. This method can however be employed only with knives having iron handles. Mechanical devices for the cleaning of such steel and iron articles are plentiful, but in their construction we must see that they are simple, practical and handy and that they are not too hard on the articles to be polished.

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